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CONTENTS

1. **Management**—Gas industry progress, business problems, statistics, government regulation, safety, personnel, education..... 173

2. **Energy Supply and Economics**—Resources, reserves, and competitive applications of the fossil fuels and other sources of energy, including nuclear and solar energy..... 177

3. **Natural Gas and Petroleum Production**—Geology, exploration, drilling, well management, reservoir engineering..... 180

4. **Gas Conditioning and LPG Recovery**—Condensate, dust, CO_2 and sulfur removal, dehydration, odorization, oil fogging, humidification; LPG recovery and refining..... 181

5. **Natural Gas Transmission**—Pipelines, compressors, dispatching, flow regulation, communications, maintenance..... 182

6. **Gas and LPG Storage**—Holders, pressure tanks, underground storage; liquefaction, refrigerated storage..... 184

7. **Manufactured Gas and Chemical Processing**—Gasification of coal, oil; reformed gas; chemical treatment; byproducts; synthesis gas production and conversion; petrochemicals; catalysts, catalyst development..... 185

8. **Gas Distribution**—City utility systems: design, operation, maintenance; weather influence on peak loads and supply; LPG-air mixtures..... 190

9. **Gas Fuel Utilization and Appliances**—Domestic, commercial, industrial; burners; combustion research; air pollution..... 190

10. **Equipment and Instrumentation**—Production and handling equipment, and maintenance; computers; controls; measurement..... 193

11. **Materials of Construction, and Corrosion**—Metals, refractories, plastics; corrosion measurement, prevention..... 194

12. **Analytical Methods and Tests**—Standard and research techniques for gas-making materials, products, processes; instrumental analysis..... 196

13. **Basic Science**—Chemistry, physics and basic engineering related to gas technology; physical properties of gases: phase equilibria, thermodynamics, reaction kinetics, heat and mass transfer, fluid flow..... 196

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Publications Abstracted for Gas Abstracts.....**Back Cover**

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1. MANAGEMENT

Competition

Economic Relationship between Petroleum and Natural Gas. P. H. Frankel, *Rivista dei Combustibili 15,* 578 (1961) June (9 pp Italian text).

The economic relationships between petroleum and natural gas are reviewed in the light of the very close linkage of the two products, both from the production and use angle. The difficulties and problems which hindered natural gas making an inroad on the power market have of late been overcome by improvements in transport methods and new utilization techniques. The advantage enjoyed by petroleum and the equivalent handicap ensuing for natural gas are therefor fast being eliminated by long-haul transport both over pipelines and in liquefied form by tankers. The advantages of the latter method, although more expensive, provide more flexibility and can be used over a larger area along the coastline. A warning is given on making a careful appraisal of reserves and markets before investing large sums of capital in expensive long-haul transport facilities.

Cost Accounting

How to Estimate Operating Costs. S. P. Dickens. *Petrol. Refiner 40,* 133 (1961) July (7 pp.)

This method of calculating operating costs, along with the literature references, permits fairly accurate estimates during project exaluation. All cost items normally associated with operating a process unit *per se* are included. However, costs for blending compounding, packaging, shipping, etc. are not included since those activities are not normally a part of the process unit operation, even though they may be quite pertinent to the profitability of the project and are sometimes included in such calculations.

Foreign Activities

Kuwait Oil in 1960. *Petroleum Times 65,* 433 (1961) June 30.

Production from all fields by the Kuwait Oil Co. totalled 80,573,627 tons in 1960, or 594,278,196 bbl. an average of 1,623,711 bbl/day. This compares with 68,437,498 tons in 1959. Production facilities completed during the year included the connection to gathering centers of 18 new wells in the Burgan field, three in the Mingish field and 27 in the north Kuwait fields.

Oil in Africa: Part 2. Oil Developments and Aspects of Petroleum Geology in North and West Africa. C. A. Fothergill. *Petroleum 24,* 221 (1961) June (4 pp.)

The impressive oil discoveries and developments in Libya were described in the first part of this article on oil in Africa and, in this concluding part, operations and aspects of oil geology in the other main areas of interest in Africa are dealt with, particularly those developments in Algeria and the Sahara as follows: Sahara Basin, Polignac Basin, Hassi Messaoud, Morocco, Nigeria, Gabon, and Angola.

Locations of Mined and Salt Cavern Facilities in the United States

(Composite from *N.F.P.A. Quarterly.* See abstract, p. 185)

Investigation into the Advantages and Disadvantages of Using Coal, Oil or Natural Gas as Raw Material for Town Gas Production in Germany. Prof. Dr. H. Pichler. *International Gas Union. IGU/37—61.* 8th International Gas Conference. Stockholm 1961 (19 pp.)

Coal still maintains a dominant role in gas production in the Federal Republic of Germany. In 1959, 89% of the gas delivered by municipal gas works and approximately 97.5% of the total common gas supply have been produced from coal. However, the use of petroleum products as raw material for gas production is increasing steadily. In connection with these developments, numerous processes have been discussed, in general such processes as have been known for some time, but only the development work of recent years has brought about greater clarification as to the pros and cons of the different processes. This paper discusses the problems in three sections dealing with (i) technological aspects, (ii) hygienic considerations, and (iii) economic investigations.

Petroleum Developments in Mexico in 1960. F. Mina U. *Bull. Am. Assoc. Petrol. Geologists 45,* 1029 (1961) July (16 pp.)

A new mark was set by Petroleos Mexicanos with the drilling of 762 wells during 1960, this being a considerable increase over the 441 wells drilled during the preceding year. An all-time high for Mexico amounted to 5,273,314 ft, drilled with an average of 6,920 ft/well. Of the total number of wells drilled 176 were classified as exploratory holes, of which 87 were new-field wildcats resulting in the discovery of 15 new oil and/or gas fields. Surface geological and geophysical exploration activities were concentrated in the coastal plain of the Gulf of Mexico although some exploration was also carried on in the Cretaceous trends in Northeastern Mexico in the state of Coahuila. Systematic gravity-meter surveys were made in north-central Chihuahua and in eastern Quintana Roo. Crude oil and distillate production in 1960 was 108,771,585 bbl., an increase of 9.7% over the previous year. Total gas production was 341,266,000 MCF with an increase of 9.6% over 1959.

The Progress of Gas Distribution in the USSR. F. A. Trebin and A. I. Sorokin. *International Gas Union. IGU/44—61.* 8th International Gas Conference. Stockholm 1961 (12 pp.)

The year 1948, when the first gas main, from Saratov to Moscow, was put into service, should be considered the beginning of industrial development of the gas industry in the USSR. At that time, commercial gas reserves were extremely limited and exploratory drilling for natural gas was carried out only on a very small scale. Gas consumption was limited to public utility services. Construction of gas mains, has been carried out on a large scale; their total length increased 3.3 times in 1959 as compared with 1955, and the pipelines are mainly of large diameter (28.35 to 40.16 in.). By the end of 1959, gas was being supplied to more than 230 towns and 166 workmen's settlements. By the end of 1965, a total population of more than 40,000,000 will be supplied with gas. Realization of such high rates of development of the gas industry is based on the availability of large reserves of natural gas in various regions and in almost all of the suitable geological formations of the USSR. The total estimated gas reserves in the USSR are 55 to 60 trillion cubic meters (1942.27 to 2118.84 trillion CF).

Where the Russian Gas Industry Is Headed. W. R. Connole. **Part 1.** *Oil Gas J. 59,* 80 (1961) Aug. 7 (4 pp.); **Part 2. Russian Pipelining Is More Than a Little Different.** *Ibid.,* 86 (1961) Aug. 14 (4 pp.); **Part 3. Soviet Gas Pattern Is Much Like Ours.** *Ibid.,* 62 (1961) Aug. 21 (3 pp.); **Part 4. Will Europe Come to Depend on Russian Natural Gas?** *Ibid.,* 58 (1961) Aug. 28 (3 pp.)

Author reports his observations made during a trip during July to the Soviet Union. He points out that Soviet gas for domestic use will soon displace enormous amounts of coal and millions of tons of oil. Russia wants to make progress in pipeline technology. Intensive work on welding techniques and other pipelining research is being conducted. Author witnessed pressure-welding demonstration, and came away particularly impressed. In the third article, he traces the impact of the gas development program on Russia's economy. He believes that while the Russians will encounter rough spots in their tremendous expansion of the gas industry, their ambitions will be realized. Europe is in danger of domination by Russia, says author in his final article. He warns that unless Europe develops its own gas supplies and a major transmission system within five years, it could wind up dependent upon Russian gas.

Impressions of the Russian Oil Industry. N. D. Smith, Jr. *J. Petrol. Tech. 13,* 621 (1961) July (4 pp.)

Author recalls his personal impressions of the Soviet Union and its oil industry received during a visit in August 1960 as a member of a group representing the U. S. oil industry. He points out that in 1959, the Russians produced approximately 1 billion bbl of crude oil, equivalent to U. S. production in 1929. In the Soviet seven-year plan, production of petroleum is scheduled to increase to 1.75 billion bbl. Exploration opportunities are roughly comparable to those in the United States in the late 1920's. In production, the Soviet industry is conservative-minded. Refineries are difficult to compare to those in the United States because the interest is primarily in distillate rather than gasoline production. Equipment is inferior to that in this country, but adequate for their present demands.

Britain's Petrochemical Boom. H. P. Hodge. *Petroleum 24,* 301 (1961) Aug. (6 pp.)

Organic chemical industry in the United Kingdom shows the most dynamic growth rates of any major manufacturing industry in Britain. Over the period from 1949 to 1959, the output of organic chemicals, including plastics, synthetic rubber, detergents, etc., increased about 250%—a growth of 11% annually. During this period the average growth rate for all chemicals in the United Kingdom was 7%/yr, as against 15% for plastics and 30% for chemicals from petroleum. This is compared with an average annual growth rate of 3% for all manufacturing industries.

National Oil Policy Is Boon to Canadian Industry. G. T. Kinney. *Oil Gas J. 59,* 134 (1961) Aug. 14 (7 pp.)

On February 1 of this year, the Canadian government invoked its first national oil policy, designed to boost lagging production. Exports to the United States were to be increased, and the Canadian market west of the Ottawa Valley in Ontario would be fenced off for domestic supplies. In only six months, the policy has succeeded beyond the expectations of its sponsors. Its impact should be more lasting than the export demand created by the curtailment of Middle East supplies when the Suez Canal was closed in 1956.

Canada Is Pipelining's Bright Star. P. Reed. *Oil Gas J. 59,* 144 (1961) Aug. 14 (8 pp.)

Large-scale pipeline construction in Canada comes in cycles, says author. This year, $126,250,000 is being spent on the Alberta and British Columbia sections of the Alberta-California system. From this high point, the Canadian oil and gas industries will be going toward another wave expected in about two or three years. At present approximately 800 miles of crude oil and condensate lines starting this summer or later will be finished this year. In about three years, the steady increase in demand for natural gas from Alberta will call for pipeline construction for a 5-year period (1964-65 to 1970) amounting to an equivalent of 1200 miles of 34-inch pipe for systems outside the province of Alberta. Inside Alberta, the Alberta Gas Trunklines Co., Ltd., would be expected to start an expansion of its system each year to handle growing deliveries of about 150 to 200 MMCF/yr. This means that after 1964 or 1965, there will be the equivalent of 120 to 160 miles of 20-inch pipe laid for this system.

Natural Gas Utilization to Begin in South Sumatra. H. P. Dunn. *World Oil 153,* 99 (1961) Aug. 1 (3 pp.)

Standard Vacuum Oil Co. is about to start the first large-scale production of natural gas in Indonesia for industrial purposes. Stanvac is committed to deliver from 12 to 15 MMCF/day from Radja field in south Sumatra to

a fertilizer plant to be built near Palembang by the Indonesian government. Gas will be moved to the new plant via a 60-mile, 10-in. pipeline from the 31 productive wells drilled in the field at the end of 1960. Hence, a petrochemical industry is being born in Sumatra. It may lead to more widespread utilization of gas in Indonesia in the future.

Federal Power Commission

The Federal Power Commission Today. Part 2. N. Regeimbal. *Gas 37,* 69 (1961) Aug. (2 pp.)

Second article of three-part series tells where the Commission stands, what it does and what its problems are at the present time. Author briefly discusses functions of Commission related to gas and power regulations.

Gas Industry Expansion

NI-Gas Develops a New Field in Gas Air Conditioning. R. E. Malmquist. *Gas Age 128,* 29 (1961) Aug. 17 (3 pp.)

Northern Illinois Gas Co. has opened a new market for gas air conditioning, says author—the home which wants central unit operation but room by room control of heating or cooling. System designed by author's company splits a central gas air conditioner into the necessary loads according to the number of apartment units. Unit was field-tested in a 4-unit apartment in Downers Grove, Ill., and functioned precisely as planned. Author briefly outlines some of the problems—such as the supply of chilled water to the necessary coil or coils and the possibility of water freezing during low load conditions—in article. Specs are included.

Natural Gas Construction Data (1961 Edition) Marketing and Statistical Dept. Gas Appliance Manufacturers Assoc. Inc. New York. ($3.00, 40 pp.)

During the year 1960, the Federal Power Commission authorized natural gas construction involving more than $787.6 millions and including 5,784 miles of natural gas pipelines. At the end of 1960, proved recoverable reserves of natural gas were at an all-time high of 263.8 trillion CF. Despite a net production of 13.1 trillion CF during the year, the proved reserves at the end of 1960 were 1.2 trillion CF greater than at the end of the preceding year. Tables are shown which list 96 cities of 50,000 population or over that received new or additional supplies of natural gas during 1960. A summary of miles and estimated tonnage of natural gas pipelines, compressors, and cost of projects completed and operating is shown as well as those not yet completed, and those still pending hearings and decisions. Activity from July 1945 to January 1961 is also briefly presented.

Gas Industry Management

The Depletion Rationale and Recent Political Pressures of Erosion. *J. Petrol. Tech. 13,* 522 (1961) June (5 pp.)

The present examination and analysis of this industry problem leads to the conclusion that the industry is caught in a historical trap of evolving political pressures which threaten either to reduce current depletion rates or to eliminate the option to expense for intangible drilling and development costs. In a free society, there are only two basic methods of escape from such a trap. One method is to settle for the best possible compromise with opposing political forces. The only other alternative of escape in a free society is through science and education. Currently, there appears to be no industry consensus on which of these alternatives to accept.

Gas Industry Progress

World-Wide Offshore Drillers "Bullish". P. Swain. *Oil Gas J. 59,* 98 (1961) July 10 (6 pp.)

Big-time oil is the pay-off for some of the drillers in the Persian Gulf and the Gulf of Paria. Disappointment is the lot of others. This report spots the significant finds and failures in these waters and such other areas as the Sea of Japan.

Information

Seeking New Ways Out of the Literature Clutter. *Chem. Week 89,* 75 (1961) July 8 (4 pp.)

New developments signify progress on one of the technology's toughest problems: dissemination and retrieval of information. The advances—mainly modifications of programs begun sometime ago—range from improved abstracting systems to more flexible chemical nomenclature plans. All are designed to help researchers keep closer tabs on the data in past and current issues of the world's 25,000 scientific journals.

Some Thoughts on the Information Problem. J. C. Costello. *Materials Res. & Standards 1,* 476 (1961) June (4 pp.)

The classical methods of classification are the Dewey or Universal Decimal Systems and alphabetical filing of subject headings. These approaches and modifications or combinations of them, have been traditionally employed in almost all applications. A third approach to the problem, concept coordination was first put to practical use just prior to World War II in England and has been gaining rapid acceptance in recent years. Concept coordination has demonstrated that it can solve adequately the over-all document storage and retrieval problem, at a reasonable cost. As a result, its use is being extended rapidly in many fields.

Maintenance

Reports for Maintenance Cost Control. E. A. Rachal and W. E. Dougher. *Petrol. Refiner 40,* 165 (1961) July (4 pp.)

The trend to automation in processing plants has greatly increased maintenance costs. Management has developed a high interest in the control of these costs because of their effect on over-all product cost. Du Pont decided that because the computer represents the most modern method for compiling data, it would be a very valuable tool for maintenance cost analysis. The type of reports needed were developed and skilled electronic data-programers were asked to solve the problem on how to get them.

Methane Liquefaction

Report of the Committee for the Study of the Interchangeability of Gases. *International Gas Union. IGU/28—61.* 8th International Gas Conference. Stockholm 1961. (15 pp.)

The overall situation regarding natural gas supplies is reviewed and note is taken of the importance of this form of energy in countries where it is indigenous. This also provides an indication of the potential use of natural gas in other countries by techniques of liquefaction and sea transport of the liquefied gas. This method of transporting natural gas has been proved by the successful trials of the "Methane Pioneer"; these have provided information necessary for ensuring the success of large-scale shipping projects. Consideration is given to the factors affecting the cost of this form of transportation and particularly the price of gas at the source and the distance of the haul. These factors are also related to the economics of gas transmission by pipeline and it is found that for the shorter distances up to 1000 to 1200 miles, the advantage lies with pipelines, but for longer distances ship transport becomes more economical.

Pipeline Systems

Calculation of the Economics of Long-Distance Gas Transmission Systems. H. Descazeaux and J. Ramond. *International Gas Union. IGU/26—61.* 8th International Gas Conference. Stockholm 1961 (24 pp.)

It is impossible in such technico-economic studies to determine certain basic information for the transmission project under consideration. Before finally deciding on a practical structure, examination of widely varying combinations of some possibly characteristic values of the most poorly defined parameters should be made. Electronic computation could provide the best answer to such problems. However, as far as the economic calculation of complex transmission systems with dynamic objectives is concerned, it is certain that it will be necessary to resort to the use of computers. In the particular case of elementary transmission systems with static objectives (unitubular, constant-output, point-to-point transmission) Gaz de France found it suitable to use its own simplified mathematical method of rapid calculation, the technique and principal results of which are given. This method allows determination, by simple functions of the physical and economic parameters derived from the data of the transmission system, of optimum characteristics.

Promotion

Gas Sales Promotion Techniques. R. Dury and J. Charlier. *International Gas Union. IGU/24—61.* 8th International Gas Conference. Stockholm 1961 (11 pp.)

The concentration of production and transport facilities, the exploitation of the Lacq and, in the near future, of the Sahara natural gas deposits, all govern, to a large extent, the choices that must be made to ensure harmonious development of gas sales in France. The sales promotion techniques described are of a universal nature, but the relative weight to be brought to bear on each of the various means to be used will depend chiefly on the economic conditions prevailing in the gas industry and in the country considered. The methods to be used will also depend on the size of the undertaking involved, since a large undertaking can have the necessary specialists available and can take advantage to a greater extent of a favorable climate as regards publicity, for example.

Heat Services by Gas in Houses and Flats in Great Britain. L. W. Andrew and D. R. Wills. *International Gas Union. IGU/27—61.* 8th International Gas Conference. Stockholm 1961 (27 pp.)

This paper considers the present position of gas and its future possibilities as a growing factor in providing the various heat services in flats and houses in Great Britain —both in existing and new property. It assesses the pattern of heating which has been accepted as conventional and the technical evidence which is leading to important changes in this pattern. The present average domestic gas consumption is 110-120 therms per annum, and the greater part of this still comes from gas cooking. In order to increase this consumption, it is necessary not only to maintain the popularity of gas cookers but to develop new loads for gas in competition with solid fuel, oil, and electricity. It will be shown that this can be done as a new opportunity now exists, particularly in the space heating field, which itself represents the greatest load of any of the domestic heat services.

Increasing the Domestic Load. L. W. Andrew. *Gas World 153,* 869 (1961) June 10 (4 pp.)

Gas has a growing and legitimate part to be played in providing wider heat services in competition with other fuels and, if this is done, more and more domestic gas sales will increase as a result of satisfied users. In order to achieve this, everything possible must be done to ensure that the correct choice of appliance is made, that the installation is completely satisfactory, and that there will be a continuing and adequate service from the British Gas Board to the user.

Research

Economics of Industrial Research Development. Y. Brozen. *Research/Development 12,* 64, (1961) Aug. (12 pp.)

In the past decade research and development performed for industrial laboratories in the United States grew at a fantastic rate. In current dollars, outlays jumped from 2.1 billion in 1950 to 9.5 billion in 1960, a compound annual growth rate of 16% as compared to 6% annual growth of gross national product. Industrial R&D grew nearly 3 times as rapidly as GNP. The number of industrial R&D employees increased to nearly 4 times the 1950 number in this period, from 200,000 to 780,000. Scientists and engineers among these employees grew 3 times as large from 100,000 to 300,000. The total United States labor force by comparison grew by only one-eighth.

Safety

Organizing Work Safety, Equipment Upkeep. R. G. Crawford. *Ind. Gas 39,* 7 (1961) June (3 pp.)

The most important factor in all gas safe practice procedures is having a well-trained competent operator. All safety aids are to help his reasoning power. The age of pushbuttons has not yet replaced him. Mindful of this,

the paper was directed toward promoting an understanding of the steps required to establish a program leading to safe operation, adequate maintenance, and a trained operator.

Plasma Spraying Techniques for Toxic and Oxidizable Materials. A. R. Stetson and C. A. Hauck. *J. Metals 13,* 479 (1961) July (4 pp.)

Plasma spraying has made it possible to deposit materials which were heretofore considered unsprayable. Two categories of materials are discussed—materials which have a toxicity problem associated with their handling, and those which undergo rapid oxidation and composition changes when sprayed in air. In the first category are beryllium and beryllium oxide. In the second are titanium carbide, tantalum carbide, zirconium carbide, and titanium nitride.

Combustible Gas Detectors. J. E. Zatek, *Ind. Eng. Chem. 53, 57A* (1961) August (3 pp.)

The complex nature of modern production processes has created a need for continual sampling and analysis for the presence of combustibles in air as a safeguard against explosive and toxic hazards. Instruments today have eliminated much of the guess-work in detecting the presence of flammable gases or vapors, and have made it possible to determine much lower concentrations of these combustibles than was formerly possible. Today's compact and simplified combustible gas indicators have a wide field of application for measuring hazards created by the presence of flammable gases in mixtures with air.

Report of the Committee for the Study of Safety Conditions in Domestic, Commercial, and Industrial Gas Installations. *International Gas Union. IGU/5—61.* 8th International Gas Conference. Stockholm. (1961) (40 pp.)

It became apparent from the Committee's early deliberations that the majority of accidents arise from the faulty or improper use of gas appliances and that consideration of the means whereby such incidents could be minimized would form an important part of the Committee's work, but it also recognized that accidents do occur due to the presence of unburnt gas, and that in these cases the composition, particularly the carbon monoxide content, is of considerable importance. The committee decided as one of the best safety measures to study compositions, as well as odorization for more safe utilization.

Standards

The General Adoption of the Units of the "Système International d'Unités" in the Gas Industry. D. Tinbergen. *International Gas Union. IGU/32—61.* 8th International Gas Conference. Stockholm 1961 (20 pp.)

The report assumes the desirability of introducing the International System and deals rather with the consequent problem of how to speed up its introduction, in particular in the gas industry. Nevertheless, Sections 1, 2, and 3 are devoted, perhaps unnecessarily, to a short summary of the system and its importance to the gas industry. Section 4 gives a general picture of the units situation in different countries. The actual problem of speeding up introduction of the system is dealt with in Section 5; the opposition likely to be encountered is discussed, and then methods of introduction. Finally, in Section 6, the urgent need for more collaboration and more international agreement on the use of units and symbols in the gas industry is pointed out. Appendix 1 gives some of the physical quantities frequently used by the gas industry, expressed in new units. Appendix 2 gives a suggested detailed procedure for introducing the system.

2. ENERGY SUPPLY AND ECONOMICS

Energy Sources

Energy and Fuels in the United States, 1947—1980. Texas Eastern Transmission Corp. (1961) July (78 pp); *Oil Gas J. 59,* 46 (1961) July 17 (2 pp.)

This study recognizes the distinction between *Energy Requirements* and *Fuel Consumption.* Working within the framework of each of the four energy "markets" (Residential, Commercial, Industrial, and Motive) the study first establishes the economic forces which determine the ultimate need for heat and power in each. Then, from these determinants, projections of end-use *energy requirements* are developed for each market, after which the *sources of supply* for these needs are considered. From these and subsequent steps follow projections for individual *fuels.* The total end-use need for energy in the four consuming sectors was equivalent to 26,200 trillion Btu in 1949. The sum of separate projections of end use energy requirements in each consuming sector is expected to reach 47,000 trillion Btu in 1970, and 64,500 trillion Btu by 1980.

Exotic Rocket-Propulsion Systems. F. J. Hendel. *Chem. Eng. 68,* 135 (1961) July 24 (8 pp.)

For long space flights, some form of ion, solar, plasma, nuclear or photon engine will be used. Far from being "operational," these engines present many formidable problems of energy conversion and temperature containment. The following types of rockets are future possibilities: solar heating, nuclear propulsion, thermonuclear propulsion, electrical propulsion, and photon rocket. If we assume that conversion of energy into kinetic energy of the exhaust particles works without losses (an assumption not justified with present technology), we find the following conversion factors for the transformation of mass into kinetic energy:

Type of Propulsion	Conversion Factor (Mass Energy)
Chemical	5×10^{-11}
Plasma	5×10^{-10}
Ion	5×10^{-8}
Nuclear	
fission	10^{-3}
fusion	4×10^{-3}
Ideal Photon	1

Finding Ways to Power Satellites. *Business Week, 118* (1961) July 22 (2 pp.)

NASA's highly successful Transit IV-a gets its electricity from atomic reaction. It is an important milestone in the development of reliable energy to power spacecraft. Three satellites were mounted in tandem atop a Thor-Able-Star rocket as it stood on its pad at Cape Canaveral. The trick was to see if they could be launched as a single multiple payload—then separated into independent orbits once they had been ejected clear of the earth's atmosphere. All three were placed in orbit, but an equipment failure caused two to fail to separate. The Transit IV-a utilizes plutonium-238 that in the process of spontaneous decay creates heat.

Photochemistry and Space Power Generation. J. N. Pitts Jr., J. D. Margerum, and W. E. McKee. *ARS Journal 31,* 890 (1961) July (7 pp.)

Some of the fundamental aspects of photochemistry are reviewed with reference to the direct use of solar radiation for the initiation of chemical reactions from which power can be generated. Photoregenerative fuel cells and photogalvanic cells are defined, and they are discussed in terms of criteria of usefulness, calculations of theoretical efficiencies and limiting factors. The nitrosyl chloride system is used as an example to illustrate the theoretical calculations of efficiency and maximum power available from a solar regenerative fuel cell. The development of a fuel cell operating on nitric oxide and chlorine is reported. The competitive process of nitric oxide-chlorine recombination following the photodecomposition of nitrosyl chloride is also considered. The problem of direct energy storage in photogalvanic batteries is discussed, and some areas of research for the development of photogalvanic cells are recommended.

Tomorrow's Power Sources—An Engineer's Notebook of Fact, Idea, and Speculation. R. Kamo. *Prod. Eng. 32,* 51 (1961) June 26 (10 pp.)

A survey of 4 basic power sources shows that for any portable machine which requires from 1 to 500 hp, the choice will probably be limited to one of the following: fuel cell, thermoelectric generator, thermionic converter, MHD generator, solar cell, 2 or 4 cycle gasoline engine, diesel, gas turbine, free piston, rotary engine, hot air (Stirling engine), vapor engine, or chemical "explosive" engine.

Energy Supplies

Origin, Development, and Work of the Energy and Industrial Engineering Division of the Verein Deutscher Eisenheutenleute. F. Wesemann. *J. Inst. Fuel 34,* 235 (1961) June (4 pp.)

The reason for the foundation of the "Warmestelle Dusseldorf" (Heat Division, Dusseldorf) was the shortage of fuel after World War I. In 1919 the new service headed by Kurt Rummel began its advisory and research activity based on the mutual exchange of experience between some 120 member works who, at the same time, established their own heat divisions, the main activity of all divisions was to keep their members informed of various aspects of techniques, prices, and new research. Since World War II the activity of the Heat Division, Dusseldorf, had to be adapted to the advances of fuel oil, the increase in fuel prices, and the development of measuring and control technique including the evaluation of mechanical data. In addition, new subjects had to be dealt with either to meet public needs such as air and water pollution control, or to protect the operator against heat and noise.

Fuel Cells

Intermediate Temperature Fuel Cells. G. V. Elmore and H. A. Turner. *J. Electrochem. Soc. 108,* 669 (1961) July (3 pp.)

Gas fuel cells are described which utilize aqueous electrolytes and operate at atmospheric pressure at over 100°C. Under these conditions the product water escapes as vapor, thus avoiding dilution of the electrolyte and flooding of the electrode pores. Both acid and alkaline electrolyte compositions have been employed. The electrolyte contains a solid phase which reduces creep, and the electrodes are made nonwetting by use of Teflon. Current densities of 50-100 ma/cm^2 have been realized.

The Temperature Coefficients of Electrode Potentials. II. The Second Isothermal Temperature Coefficient. G. R. Salvi and A. J. de Bethune. *J. Electrochem. Soc. 108,* 672 (1961) July (5 pp.)

The second isothermal temperature coefficient of the potential of an electrode is equal to $\Delta C_p/nFT$ where ΔC_p is the heat capacity of the "SHE/Electrode" cell reaction. The mass action dependence of the second coefficient is given. Values of the second coefficient are tabulated for 58 standard electrodes, together with the first coefficients. Application of the data to fuel cells, and to emf-temperature relationships, is discussed.

Heat Storage

Off-Peak Electric Heating. E. R. Ambrose. *Air Conditioning, Heating, and Ventilating 58,* 51 (1961) July (6 pp.)

Storing of heat developed from electric energy during night and other off-peak hours and drawing on this heat during periods of heavy heat requirements is a subject of interest to both the heating engineer and the electric utility companies. Such a method makes it possible to reduce the daytime electric demand and at the same time materially increase the annual load factor of the generating facilities, resulting in a lower electric heating cost to the customer. In some instances, it may enable the utility to offer an attractive off-peak energy rate. Present methods actually in use are summarized.

Offshore Operations

Multirig Platforms Save for Calco. E. McGhee. *Oil Gas J. 59,* 93 (1961) July 10 (3 pp.)

Four rigs can't operate as cheaply as one, but four rigs on one platform are cheaper than one rig on each of four platforms. That is the experience of the California Co. at Bay Marchand off Louisiana's coast. Unit operating cost is kept low by running two drilling rigs and two completion rigs on one platform from one tender.

Spliced Concrete Piles Fill Offshore Construction Gap. E. McGhee. *Oil Gas J. 59,* 96 (1961) July 10 (2 pp.)

The combination of shallow offshore water and long concrete piles presented construction problems for Shell Oil Co. in erecting platforms. Since shallow water derrick barges could not handle the piling in a single piece, piles were made in two sections and then spliced together on the job. The result was an inexpensive, effective platform support.

Oil and Gas Discoveries

Niobrara Discoveries Enhance Northwest Colorado Prospects. B. Coltman and W. D. Pitt. *World Oil 153,* 80 (1961) July (3 pp.)

New oil and gas discoveries continue to be made in northwestern Colorado. Numerous prospective zones are found throughout the section from Pennsylvanian to Tertiary. Future development of the Niobrara formation will likely include not only Sage Creek, Fish Creek, and Tow Creek anticlinal areas, but also other more obscure anticlines and structural noses as well. Recent exploratory drilling Routt County indicates the presence of several new, on-structure areas of fractured Niobrara shale production.

Oil Shale

Apparatus and Method for Retorting of Oil Shale. W. S. Dorsey (assigned to Union Oil Company of California) U. S. 2,989,442 (1961) June 20.

A continuous retort for removal of oil from oil shale is claimed, which includes a vertical chamber piston fed upwardly with fresh shale lumps. A hot gas stream feeds downwardly through the deep bed of shale to remove oil and gases through an intermediate slotted-wall eduction zone. The spent shale is scraped from the open top of the deep bed to a spillway leading to a combustion zone. Hot gases from combustion of residual shale carbon are mixed with educted gas and cycled through the bed as eduction fluid. Gas temperatures are damper-controlled to hold at 1050°-1250°F in eduction zone.

Petroleum

Impact of Soviet Oil. I. H. Cram. *Bull. Am. Assoc. Petrol. Geologists 45,* 1018 (1961) July (11 pp.)

An assessment of the importance of Soviet oil and gas potential can be summarized as follows: should planning involve more exportation, additional advantages may be gained in foreign exchange and for necessities the Soviet's position can be solidified in the satellite countries; and more economic and political advantages can be made at the expense of the Free World. If, however, the oil is kept within the country, industrial strength can be built up, and their position consolidated with the people by a raised standard of living. Since the Soviet planners strive for balance, chances are both will be done, and industrial progress and influence will grow. Caution must be exercised at all times to avoid underrating of the Soviet potential.

Thermocatalytic Radiation

Gas-Fired Thermocatalytic Reactors — A Flameless Incandescent Source of Thermal Energy. G. Weiss. *International Gas Union. IGU/22—61,* 8th International Gas Conference. Stockholm 1961 (24 pp.)

Thermocatalytic combustion is a radiant heating process based upon a catalytic reaction accelerated by thermal coupling between the surface and the substratum of the reactor. The process differs radically from other so-called flameless systems through certain important characteristics which devolve from the fact that the heat given off by the thermocatalytic reactor is of an intensely radiant nature. Moreover, this thermal reaction is capable, in practice, of delivering power densities of the order of over 1,000 Btu/hr per square inch, on the surface of the reactor itself. A fully enclosed, flameless reactor of the Pyrocore type operating at about 2,000°F is capable of transmitting by radiation, to the surface of a juxtaposed heat exchanger, a very great portion of the total thermal energy production—about 70 to 75%. Taking advantage of this quality, it has become possible to design gas appliances for domestic and industrial heating and refrigeration which attain levels of compactness, safety, efficiency, and ease of automatic control never before considered possible.

Thermoelectricity

Thermionic Converters for the Direct Generation of Electricity from Gas. George N. Hatsopoulos and John A. Welsh. *International Gas Union. IGU/21—61.* 8th International Gas Conference. Stockholm 1961 (11 pp.)

The direct conversion of heat into electrical energy offers many advantages over the more customary approach which involves an intermediate conversion of heat into mechanical energy. Since direct conversion devices do not involve moving mechanical parts, they are silent, do not require lubrication, and can operate for long periods of time with practically no supervision. They also offer the prospect of higher efficiency in the small power field, smaller weight and size, and a more compact design requiring relatively little maintenance. They can be easily scaled up or down in size to practically any power level that may be required, and can use practically any source of heat ranging from the combustion of fossil fuels to nuclear reactors. Direct conversion of heat into electricity has attracted considerable attention and a large research and development effort, particularly in the field of thermionics, by both commercial and military agencies. The present paper describes the principles of operation of thermionic converters and their use for the direct generation of electricity from gas.

3. NATURAL GAS AND PETROLEUM PRODUCTION

Drilling

How New Foaming Agents Are Aiding Air/Gas Drilling. J. L. Lummus and B. V. Randall. *World Oil 153,* 57 (1961) July (6 pp.)

Pan American Petroleum Corp. research engineers have tested in the laboratory and in the field, hundreds of foaming agent compounds to determine those most effective in combatting the influx of water in wells being drilled by air or gas. If present trends continue, indications are that a total of 14 MMCF of hole will be drilled with air during 1963. Use of improved foaming agents, further utilization of air percussion tools and improved bits will play major roles in the future of air drilling.

Slim Holes Can Cut Hard-Rock Drilling Cost. F. M. Pool. *Oil Gas J. 59,* 81 (1961) July 17 (3 pp.)

Many drilling contractors have yet to realize that, even though there is romance in big engines and big derricks, there are not proportionate profits. With a rig properly sized to match horsepower and hydraulic requirements, the contractor can drill slim holes cheaper than conventional sized holes. The saving, contrary to what many believe, does not apply only to drilling soft formations. It also applies to medium-hard to hard formations, including the Permian and Pennsylvanian sections in western Texas and eastern New Mexico.

Drilling, Mud

Drilling Mud Weight Presents Unusual Problems. H. G. van Laar and R. R. Lewis. *World Oil 153,* 45 (1961) July (3 pp.)

Drilling conditions in the Agha Jari field in Iran are troublesome and expensive. Thus a thorough evaluation of the mud program is necessary. Severe lost circulation, extreme high-pressure flows, and salt beds of a thousand feet or more are the conditions that dictate the mud program. At about 6000 ft the top of a formation, termed the Lower Fars, begins. This formation overlying the limestone reservoir, consists of marls, anhydrite, and salt. Depending on the location, the Lower Fars may be anywhere from a few hundred to a thousand or more feet thick. Salt water is present in this formation with pressures approaching overburden pressure. To control these abnormal water pressures, muds ranging in density from 130 to 165 lb/CF have been used. Because of the extensive salt beds, these muds must be of the salt saturated type to prevent severe washouts.

Exploration

Electrical Logs. D. A. Busch. *Oil Gas J. 59,* 162 (1961) July 10 (4 pp.)

Very precise correlations of many subsurface formations are now possible and geological phenomena such as unconformities and facies changes usually can be readily recognized by them. Electrical logs are proving to be indispensable in defining stratigraphic trap prospects. In this type reservoir, a detailed knowledge of the paleographic environment of deposition is essential. Electrical logs afford the necessary markers for identifying and analyzing genetic sequences which, in turn, are necessary to the reconstruction of the surface of deposition of reservoir sands.

Geology

Reef Fever Spreads into East Texas. C. Stevens. *World Oil 153,* 68 (1961) July (3 pp.)

Reef fever, first recorded at Leduc in 1947, and later reaching epidemic proportions at Kelly-Snyder and Lovington/Empire, is spreading to a new area—one which in the past would have been considered virtually immune. The new locale is East Texas, in the heart of the interior salt-dome province. The reef is a James line development of lower Rodessa, Glenrose-Trinity Group of Cretaceous.

Pipeline Engineering

French Survey Successes Bring World's No. 1 Undersea Gasline Nearer. M. Moyal. *Gas J. 306,* 471 (1961) June 28 (5 pp.)

French offshore pipelayers have found basic ways of crossing the Mediterranean Sea. Feasibility studies have shown that the first submarine transmission line in the world would be capable of moving more than 350,000 MMCF of Hassi R'Mel natural gas/yr to Western Europe. The bringing on stream of the 320 mile long 24- and 20-in. Hassi R'Mel-St. Leu gasline has opened at least 28 billion CF of natural gas. Ranking only second to Texas' Panhandle, the tremendous Hassi R'Mel field is capable of easy commercial exploitation to the tune of 700,000 MMCF per year for 50 yrs. Even with the construction of two 16-in. spurs to bring gas to industrialized Algiers and Oran, and of another Hassi R'Mel-Bone gasline to power the steel complex and supporting industries currently going up at this Mediterranean harbor, Algeria itself will be capable of using at the most 73 billion CF/yr, or slightly in excess of 10% of the available supply.

Reservoir Engineering

How to Locate Reservoir Limits. J. E. Cornett. *Petroleum Eng. 33,* B-19 (1961) July (6 pp.)

Recordings of bottom-hole pressures provide data for a unique method of calculating reservoir limits, estimating in-place oil or gas, and locating development wells for most efficient drainage. Case histories validate this technique.

Salt Content Change Compressibility of Reservoir Brines. G. Long and G. Chierici. *Petroleum Eng. 33,* B-25 (1961) July (7 pp.)

The volumetric behavior of brines in petroleum reservoirs can make a big difference in the accuracy of reservoir engineering calculations. Reservoir water compressibility, formation volume factor (FVF), and density are functions of temperature, pressure, the amount

and composition of dissolved solids, and the volume and composition of dissolved gases. Except for a partial approach by Bjerknes and Sandstrom on sea water, no systematic experimental determination has been developed so far. This study goes further to determine the influence of salinity on reservoir water volumetric behavior by developing a number of equations.

4. GAS CONDITIONING AND LPG RECOVERY

Carbon Monoxide Removal

The Production of Town Gas with Reduced Carbon Monoxide Content. F. Jordi. *International Gas Union. IGU/41—61.* 8th International Gas Conference. Stockholm 1961 (12 pp.)

After reviewing generally the known feasibility of producing town gas containing little or no carbon monoxide, results of Basle gasworks plant, which has now worked for 2¼ years, without interruption, on the catalytic conversion of carbon monoxide with steam are given. The converted town gas contains about 1 per cent by volume of carbon monoxide and less than 3 grams of organic sulfur in 100 Nm^3 (1.25 gr/SCF). In a first catalyst layer, oxygen burns out with the corresponding volume of gas, while nitric oxides are converted into harmless compounds. Since the distribution of town gas containing only about 1% of carbon monoxide began, no poisoning nor any suicide by gas has occurred, and troubles with gas appliances, as well as with the internal corrosion of gas mains, became remarkably fewer. In 1959, conversion increased the prime-cost of the town gas by 1.23 Swiss ¢/37.22 CF for a total output of 1771.67 MMCF.

Hydrogen Cyanide Removal

HCN Removal. Herbert A. Gollmar (assigned to Koppers Company, Inc.) U. S. 2,989,147 (1961) June 20.

In the cleaning of blast-furnace gas by water washing, the removal of hydrogen cyanide (HCN) from the water is required for the recovery and recycling of the large amounts of water. The removal of HCN is improved by addition of 0.25% carbon dioxide by volume to the air used to aerate the water. The HCN, greatly diluted by the air, can be vented to the atmosphere.

Hydrocarbon Removal

A New Process for Removing Gasoline from Natural Gases Dissolved and Associated with Petroleum. I. A. Niculescu and N. Petcu. *International Gas Union. IGU/40—61.* 8th International Gas Conference. Stockholm 1961 (8 pp.)

Researches are reported on a new process for hydrocarbon separation by means of adsorption on active carbon, to meet the industry's requirements for intensive and economical separation. The new procedure involves adsorption at temperatures above 60°C. These high temperatures allow methane to be removed from the gas, as well as for high recoveries of C_2, in singlestage operations. In addition, the high adsorption temperatures render unnecessary the drying and cooling of active carbon prior to its use for adsorption. The gas is preheated and led to vessels containing the active carbon. The adsorbed products are removed from the carbon by superheated steam. Adsorption is resumed immediately, without drying and cooling the carbon. Due to the high temperature at which adsorption is carried out, and the low hydrocarbon saturation of the active carbon, the latter retains during desorption just enough humidity to replace that surrendered during adsorption.

99.6% Pentanes-Plus Recovery Obtained with Short Cycle Adsorption. G. F. Russell. *World Oil 153,* 48 (1961) July (4 pp.); *Oil Gas J. 59,* 120 (1961) July 10.

A new short cycle recovery unit installed by Continental Oil Co., in the Driscoll field of South Texas is recovering 99.6% of the pentane-plus fraction from a natural gas stream with a gasoline content of only 0.100 gal/MCF. The unit automatically and alternately uses both steam and hot gas to regenerate adsorbent beds of activated carbon and activated alumina. The effluent gas also contains only 3.0 lb/MMCF water although minutes before, direct contact steam has been used to regenerate beds. After 11 months operating, the bed activity shows no loss.

Hydrogen Sulfide Removal

Processing Methods for Particular Gases According to Their Nature and Utilization Characteristics. Assoc. Tech. Ind. Gaz en France. *International Gas Union. IGU/7—61.* 8th International Gas Conference. Stockholm 1961.

This paper reviews the various methods used to eliminate the impurities contained in particular gases, mainly those manufactured by cracking or reforming hydrocarbons, natural gases, and coal gas under pressure. The main topics considered are: enumeration of the impurities and their importance according to the manufacturing method used and the raw materials employed. Distinctive features of the processing methods for manufactured gases, for natural gas (elimination of hydrogen sulfide, chiefly Lacq works), for coal gas intended for underground storage (Beynes storage). Conclusions stress the diversity of the various achievements; they tend to show that the conditions under which manufacture itself takes place and the means used to rid the gases of their impurities are closely dependent upon one another.

Natural Gas in France and Its Treatment. L. Barbouteau and R. Guillo. *International Gas Union. IGU/25—61.* 8th International Gas Conference. Stockholm 1961 (16 pp.)

Natural gas is processed chiefly near Pau in Southwest France. The composition of this gas, and its hydrogen sulfide content in particular, call for two desulfurization stages, the first involving scrubbing with water, and the second being a final desulfurization with amine. Desulfurization with high-pressure water requires special equipment and has called for research into the balancing

of water and unprocessed gas and into pure technology. Much study was especially devoted to safety precautions. Actual operation has shown that scrubbing with water removes virtually 50 per cent of the acid gas contained in the unprocessed gas. However, since the temperature of the circulating water is one of the main factors in this absorption, it is preferable to adapt a system to this unit capable of removing the heat of absorption. The solution is cooled in the turbines, which recover the work arising from the two successive reliefs sustained by the acid gas-enriched solution. These two reliefs are necessary to permit regeneration of the scrubbing water without any heat contribution.

5. NATURAL GAS TRANSMISSION

Automation

Instrumentation and Supervisory Control: Features of the New Peoples Gas Dispatching System. H. M. Joiner and L. B. Lumpkin, *Pipeline News 33,* 21 (1961) July (7 pp.)

The object of this study was the development of a system to provide the customers of Peoples Gas with the most reliable, the most efficient and as a result the most economical supply of natural gas possible. Cooperating closely in these studies were technical representatives of The Bristol Company, with the assistance of The Westinghouse Electric Corporation which furnished the communications and supervisory equipment. The system involves the automatic remote operation of five major regulating and metering stations. These are Vinco, McKeesport, Chalfant, Mt. Royal, and Blackhawk. This system has handled a peak load of over one half billion cubic feet of gas per day, to cover a quarter of a million customers in 274 communities in 15 counties in Western Pennsylvania. The entire system operates on a digital basis with all measurement, control, alarm, deviation, command, and logging functions handled in this manner.

Supervision and Regulation of a Natural Gas Transmission System with Particular Reference to Automatic Mixing Plants Using Multiple Short Wave Frequencies. A. Lazek and F. Huber. *International Gas Union. IGU/15—61.* 8th International Gas Conference. Stockholm 1961 (12 pp.)

With the withdrawal of the Occupation Forces from Austria in 1955, and the resulting transfer of crude oil industry to the Austrian state, the significance of natural gas for the power industry of Lower Austria increased considerably. Within 3 years, the high-pressure pipeline system was constructed with the installation of an effective system of controls. The v.h.f. equipment created for the NIOGAS distribution area serves both plant control and regulation of the entire high pressure network operation. The natural gas pressure-reducing stations are fully automatic. If the permissible back pressure is exceeded, an alarm signal shows. As the development of the natural gas industry was in full swing at the time the v.h.f. control system was installed, future connections had to be provided—particularly with respect to telemetered transmission. Telemetric values are transmitted without continuity, each enquiry cycle having a transmission time of 10 minutes.

Compression

The Utilization of the Jet Compressor for the Transmission of Natural Gases in the Roumanian People's Republic. A. Pascaru and P. Svoronos. *International Gas Union. IGU/39—61.* 8th International Gas Conference. Stockholm 1961 (10 pp.)

Supplying methane to centers of population and other consumer points situated near methane reserves is rather easy because the gas may be supplied through large-diameter pipelines, at low initial pressures and capital cost. On the other hand, supplying methane to distant consumers requires rather high starting pressures and entails high capital cost. Rational exploitation of methane reserves should take into account the fact that the gas has to be supplied under natural pressure to distant consumers for as long as possible. For this reason, the methane supplied to local consumers should be taken from geological formations giving lower pressures than that of the pipeline supplying distant consumers, and the natural energy of high-pressure wells should be used for compressing gas from wells whose natural pressure is lower than that of the pipelines supplying remote consumers.

Compressor Stations

Freezing Hazard Avoided with Azeotropic Mixture. *Oil Gas J. 59,* 97 (1961) July 17.

Compressor stations on the Texas-to-California system of Transwestern Pipeline Co. are heated by self-operated, self-contained compact steam generators. Subfreezing temperatures present no hazard—even during shutdown—although the boilers are located outdoors and condensate returns through 250 ft of exposed pipe. Transwestern adopted the answer suggested by Gulf Interstate Co. to solve the freezing problem that has plagued other lines. Transwestern uses a heat-transfer medium that forms an azeotropic mixture with water and so protects against freezing.

Compressors

Compressor Maintenance. J. C. Boehm. *Gas Age 127,* 34 (1961) June 22 (6 pp.)

Pipeline economics require the highest possible load factor. One contributor to this ideal is compressor performance. 100% availability can be achieved by preventing the need for maintenance. This can be accomplished by proper design, construction, and operation to the end that maintenance when performed, should not interrupt deliverability.

Non-lubricated Natural Gas Compressors. P. J. Chandler. *Pipeline News 33,* 30 (1961) July (3 pp.)

The Arkansas Louisiana Gas Co. has been using Micarta

rings and packing impregnated with molybdenum disulfide in its compressor cylinder operation for five years with exceedingly good results. A large majority of the field compressors are equipped with Moly rings and packing. These units vary from 30 to 350 horsepower skidmounted belt driven compressors and 150 to 750 horsepower skidmounted direct driven angle units. Mainline compressor units operating non-lubricated are 330 to 1,500 horsepower angle type direct driven compressors and most have oil bath scrubbers on the inlet gas stream.

Use of Natural Gas Pressure Reduction to Operate Compressors. R. F. Miaskiewicz. *Gas Age 127,* 25 (1961) June 22 (3 pp.)

Use of turbine expansion instead of throttling to obtain pressure reduction provides a source of energy which could be put to useful work. The author discusses such application for compressor operation.

Pipeline Construction

Alberta-California Pipeline. *Pipeline News 33,* 28 (1961) July (2 pp.)

"On schedule or ahead of schedule" is the word from all sections of the 1400-mile, 36-inch-diameter Alberta-California pipeline system under construction to import the fuel for customers of Pacific Gas and Electric Company. The completion target is the end of this year. Work is moving ahead at twenty locations on the 1190 miles of pipeline from the producing fields in the north to the California-Oregon border.

Big Gas Line is Yard Wide—And Going in Ground on Schedule. *Oil Gas J. 59,* 64 (1961) July 10 (2 pp.)

The biggest pipeline project under way today—the 36 in. gas line from Alberta to San Francisco—is more than halfway finished and going at a clip that assures completion on or before the target date of November 1. Eleven spreads involving 3,750 pipeliners are busy along the route of the 1400 mile pipeline.

New Design Makes World's Longest Pipe Line Suspension Span Possible. D. M. Taylor. *Pipe Line Ind. 15,* 40 (1961) July (6 pp.)

From tower-to-tower the Missouri crossing measures 2,703 feet, and one end is supported by a 273 foot tower believed to be the world's tallest structure ever to be erected in one piece. But the outstanding feature is the new design concept.

Technique of Gas Line and Compressor Station Construction in the USSR. V. S. Turkin and A. N. Yuryshev. *International Gas Union IGU/45—61.* 8th International Gas Conference. Stockholm 1961 (16 pp.)

The construction of gas pipelines in the USSR is expanding year by year. They are built all over the vast territory, in different geographic and climatic environments, and there is a trend towards further increase in their length and size. Standards and specifications regulating pipeline construction are systematically revised to keep them abreast of current developments in construction technique. Pipeline design has been modified to make tensile rather than yield strength of steel the main criterion of pipe quality. The physical characteristics of pipes have been improved, resulting in a saving of metal. Gas pipelines in the USSR are built by specialized contractors working under the guidance of the State Gas Industry Department "GLAVGAS," and involve assembly line production methods. The various operations involved in laying a pipeline are highly mechanized. Clearing and grading of rights-of-way are accomplished by means of specialized equipment. During the winter construction season, at sub-zero temperatures, special techniques and machinery are used.

The Calculation of Pipelines and the Prerequisites for Choosing Optimum Gas Transmission Conditions. A. V. Alexandrov, B. V. Barabash, I. E. Khodanovich. *International Gas Union. IGU/46—61.* 8th International Gas Conference. Stockholm 1961 (19 pp.)

An analysis of the possibilities of laying gas pipelines of graded wall thickness shows that it is possible to save 2 to 4 per cent of metal for larger diameters in excess of 500 mm (approx. 20 in.). However, complications in the operation of such pipelines renders them of little practical value. Analysis of tendencies and of the laws governing the terms in gas pipeline natural indices will enable engineers and planners to elicit the optimum alternative conditions for each particular case.

Pipeline Systems

Hassi R'Mel-Arzew Gas Pipeline. *Petrol. 24,* 251 (1961) July (2 pp.)

The 24 inch gas line from the great natural gas field at Hassi R'Mel to Arzew on the Mediterranean coast came into operation last month. With branch lines to the industrial areas of Algiers and Oran, initially the pipeline will only supply Algerian demands, expected to commence at 18 billion CF in 1961. However, when marketing problems and technical problems associated with the Mediterranean crossing are solved, a far greater throughput is anticipated. Exports of some 35 billion CF of gas by methane tankers are hoped to start in 1962.

Pipeline Design

Economical Diameters in Pipeline Systems at Given Supply and Outlet Pressures. H. A. A. de Melverda. *International Gas Union. IGU/35—61.* 8th International Gas Conference. Stockholm 1961 (18 pp.)

This paper discusses a pipeline consisting of several parts, there being at the end of each part an outlet or an additional supply; pressures at the beginning and at the end of the pipeline are supposed to be given and recompression is not assumed. The object of this paper is to find conditions of minimum investment. It is shown that in this case there is always an optimum and there is only one principal condition: the diameters of the consecutive parts of pipeline must be proportionate to the desired capacities of these parts to a certain power. A formula is given to compute each diameter. Also a formula is given to compute the optimum investment.

Transmission Problems

Hydrate Problems at Farm Taps. F. R. Bater. *Gas Age 127,* 28 (1961) June 22 (2 pp.)

Conditions conducive to hydrate formation are high transmission pressures (and hence high pressure drop through the regulator), excessive moisture in the gas, and low ambient temperatures. The usual means of prevention is to heat the inlet gas or sometimes it may be sufficient to merely warm the regulator or adjacent piping. However, sometimes the trouble is sufficiently persistent that other means are resorted to, in one instance the entire regulator set was buried with the hope that sufficient heat from the ground would be absorbed to eliminate hydrate formation. Such was the case for this particular situation.

6. GAS AND LPG STORAGE

Gas Holders

Repairing and Reinforcing the Concrete Tank of a 80,000 m³ (2,824,800 CF) Gasholder. G. Vitali. *International Gas Union. IGU/31—61.* 8th International Gas Conference. Stockholm 1961 (15 pp.)

A 2,824,800 CF gasholder water-tank, constructed of non-reinforced concrete in 1906, and semi-sunk in the ground, was found to be losing considerable water by leakage through faults in the structure. It was decided to put the gasholder out of commission and proceed with a thorough overhauling. Once the water-tank had been drained and cleaned, it became obvious that there were serious cracks. To repair these faults, cables were strung and made taut vertically and horizontally to reinforce the tank; vertical cables restored the vertical stability of the tank and horizontal cables set up an inward thrust equivalent to the hydraulic thrust on two thirds of the wall. In this way, the structure was made sufficiently rigid to withstand the stress transmitted by the telescopic guide columns, and to make the reinforced plaster lining water tight. The first trials made with the tank full of water proved that the procedure adopted was efficient.

LP Gas—Ammonia

First Large Volume Refrigerated Barges Put in Operation. *Butane-Propane News 23,* 52 (1961) July (2 pp.)

Phillips Petroleum Co. has recently taken delivery on 2 barges, the Mary Lee and the Marjorie B., to be used for the transportation of anhydrous ammonia and LP gas. These barges are designed to transport the cargo in a fully refrigerated condition. The pair will begin operation as an integrated tow to transport anhydrous ammonia from Adams terminal, on the Houston ship channel, to East St. Louis, Ill.

LP-Gas

LPG Industry Faces a Tough Summer. *Oil Gas J. 59,* 62 (1961) July 10 (2 pp.)

LPG producers are all set for a long, cold winter. The only trouble is they are just starting summer. Inventories hang at near record highs. Same is true for plant production. The upshot of a situation like this is the usual crumbling of prices at a time when it is still 3 months until fall demand can give the market any substantial lift.

Use of Prestressed Concrete Pipe for LP-Gas Storage. H. W. Wills. *Gas Age 127,* 30 (1961) June 22 (4 pp.)

The adaptation of prestressed concrete pipe for LP-gas storage is a minor departure from its primary use. It offers, substantial savings, lower insurance costs, and reduced fire hazards among other advantages. Its flexibility for such use is almost limitless. The advent of prestressing and the use of embedded steel cylinders in concrete pipes presents a new concept in the economical bulk storage of LP Gas. Prestressing provides the strength, and the cylinder provides the gas tight membrane.

Methane Liquefaction

Cryogenic Storage of Natural Gas. W. F. Morse. *A.G.A. Monthly 43,* 15 (1961) July-August (2 pp.)

The gas utility industry has two interests in LNG; the receipt of LNG by tanker from foreign gas sources and, of much more significance, the liquefaction and storage of off-peak pipeline gas for regasification in the winter during periods of peak demand. A number of northeastern gas utilities and the transmission companies serving them are seriously evaluating the installation of LNG facilities for the latter approach to storage at the point of use. Several studies are in progress at the Institute of Gas Technology evaluating the many phases of low temperature storage.

Cryogenic Storage Vessels. G. F. Sulfrian. *Chem. Processing 24,* 31 (1961) July (4 pp.)

A vessel can be properly designed only after a very careful and detailed analysis of its expected operation. Each operating requirement should be satisfied in order of importance, so that the design criteria can be developed progressively. The operating requirements can be conveniently analyzed in terms of capacity, working pressure, allowable evaporation loss, and operational procedures.

Refrigerated Storage

Insulation for Cryogenics. A. Matesanz. *Chem. Processing 24,* 28 (1961) July (4 pp.)

Cost of insulation must be balanced against product loss, choice depending upon boiling point of the fluid being handled, its value, and the type and size of equipment to be insulated. Low temperature insulation plays a key role in industrial cryogenics, which may well become a billion dollar industry by 1965. In fact, cryogenic insulation may have annual sales of $50 million itself by that time. Types of insulation now used are: mineral wool and glass fiber, perlite, polyurethane (foam), foamglas, santocel with aluminum flakes, and

super-insulation of 15 aluminum foils/in. and 60 foils/in.

Underground Storage

Liquefied Gas Storage in Caverns. G. R. Benz. *International Gas Union. IGU/20—61.* 8th International Gas Conference. Stockholm (1961) (12 pp.)

The cost of underground storage for LP-Gas is less than the cost of steel storage tanks located above ground in volumes exceeding 400,000 to 1,200,000 gal. (794—2,380 tons), with the exact cost for any particular storage system dependent upon such factors as vapor pressure of the LP-Gas to be stored, depth of suitable formation in which a cavern can be washed or mined, geological location of the facilities, rates of input and output needed, the amount and type of storage facilities required, and availability and cost of water and a satisfactory way to dispose of the brine, in the case of caverns dissolved from salt formations. It is important to make a thorough study of the underground formation before selecting a site and designing the facilities.

Storing Gas in an Abandoned Coal Mine. R. E. Kelly, *Pipe Line Ind. 15,* 46 (1961) July (6 pp.)

Public Service Company of Colorado started converting the abandoned Leyden coal mine to underground natural gas storage on April 17, 1959. By December 31, 1960, the work had progressed to the point that the mine was holding 750 MMCF of gas in storage. Pressure in the mine averages about 200 psig. The company's present plans call for a continuation of this project with an eye toward an ultimate storage capacity of 3 billion cubic feet.

The Problem of Underground Gas Storage in the USSR. N. S. Erofeev. *International Gas Union. IGU/47—61.* 8th International Gas Conference. Stockholm (1961) (8 pp.)

This paper gives a brief analysis of the factors determining the efficiency of underground gas storages as the means of meeting variations in gas consumption. The author describes a method of determining the necessary capacity and optimum productivity of storages, the suitable geological conditions and methods of prospecting and exploring for underground storages; and the results of a theoretical study of gas hydro-dynamic character in connection with underground gas storage are briefly stated. The first results of experimental gas and air injections into underground storages in the USSR are also described.

Underground Storage. A. M. Shook. (assigned to Texaco, Inc.) U.S. 2,986,007 (1961) May 30.

A method of forming a storage cavity underground by washing a salt formation is described, in which salt removal is controlled. A casing is sealed into the drilled hole into the salt at some distance above the bottom of the hole desired. A conduit placed annularly within the first conduit admits the wash water. The improvement comprises adding a layer of kerosine to protect the seals and roof from the washing, and removing the final brine by a central pipe.

Underground Storage of Liquefied Petroleum Gas. A. F. Dyer and J. W. Hale. *Nat. Fire Protect. Assoc. Quarterly 55,* 5 (1961) July (12 pp.)

During the past 15 years, LPG sales have increased 8 times over—from 1.2 billion gallons in 1945 to 9.6 in 1960. Such a growth pattern naturally has resulted in some distribution problems, and the adverse winter to summer volume ratio aggravates them several fold—⅔ of the yearly quantity being sold in winter. It is uneconomical to fit the production to the demand rate, hence it has been necessary to store the product during the off season. Above ground steel storage has been used for a number of past peak seasons, but with the demands reaching their present peaks, the feasibility, practicality, and low expense involved caused the industry to turn its thinking more and more to underground storage, which is not only safer but considerably less expensive than steel tankage.—(See Composite Map —p. 173.)

7. MANUFACTURED GAS AND CHEMICAL PROCESSING

Ammonia

Industrial Nitrogen Production Seen Doubling by 1965. G. Howe. *Chem. Processing 24,* 38 (1961) July (5 pp.)

According to official United States Government sources production of high-purity industrial nitrogen totaled 12 MMCF in 1960, as against 9.5 MMCF in 1959, and 1.3 MMCF in 1950. It is estimated that production in 1965 will hit 25 MMCF, more than double the 1960 rate. Increased use as a super-cold liquid for refrigeration and as an inert gas are the major factors in its rapid growth.

Ten Years of Gas Liquor. *Gas. J. 306,* 397 (1961) June 14 (4 pp.)

The application of gas liquor to farm crops has made astonishing strides. During 1960, 80 million gal were distributed to farms in this country (Great Britain), compared with 6 million gal in 1953—a 13-fold increase in seven years. There are still unfortunately, a few areas where it is not yet available at a competitive price. It goes by a number of different names in different parts of the country: Ammoniacal liquor (the official gas industry term), ammonia liquor, nitrogenous liquor, nitro-liquor, or simply gas-liquor. It is produced in the process of eliminating the ammonia products from town gas, and its principal components are ammonia and ammonium salts, together with minute quantities of other elements. It is these other elements which probably give gas liquor its weed and pest controlling characteristics.

Coal Carbonization

Carbonisation of Low Quality Coal and Subsequent Use of Coke in a Carburetted Water Gas Plant. D. O. Vick. *International Gas Union. IGU/10-1961.* 8th International Gas Conference. Stockholm 1961 (8 pp.)

Methods of utilizing low grade coal economically, as

well as other means of gas manufacture, due to the depletion of good quality gasmaking coal reserves and consequent increased cost of coal, is the subject of this paper based on experience with continuous vertical retort carbonization of the very poor quality coal available in Brisbane. The coal available locally to Brisbane is geologically young, in thin seams layered with incombustible material. Continuous vertical retorts and horizontal retorts have used this coal in Brisbane for many years, as the only means of gas manufacture until carbureted water gas manufacture was introduced in 1953. The coke from the continuous vertical retorts is small, friable, highly reactive and has high ash content with high fusion temperature. These coke characteristics lead to acute problems of ash extraction when the coke is used as a fuel for carbureted water gas manufacture; the operation has to be appreciably different from that employed when using a good quality coke.

A Coal Viscosimeter. J. de Brouwer. *International Gas Union. IGU/18—61.* 8th International Gas Conference. Stockholm 1961 (16 pp.)

When subjected to carbonization in ovens at temperatures of 662° to 752°F, coals change into a plastic state associated with the liberation of gas and liquids, the viscous mass retaining within itself the infusible material of the coal as charged. This paste offers but limited permeability for the passage of liberated gas; as a result, expansion forces are set up within the caking and coal zones and transmitted to the oven walls. The proposed viscometer facilitates, by a quick laboratory operation, calculation of the degree of viscosity and of the expansion pressures relating to the carbonization of various mixtures of coal with coke or iron ore. It is possible, also, to estimate stress limits for oven walls, and optimum values for production of high quality coke.

The Exploitation of Coking Plant Gas for Distribution in Czechoslovakia. S. Odehnal. *International Gas Union. IGU/43—61.* 8th International Gas Conference. Stockholm 1961 (10 pp.)

Coking plant gas plays an important part in the Czechoslovak gas industry; it is the principal source of gas (83 per cent of the total production) and is also an important factor in the piping of gas over long distances and for the distribution networks. The production of coking plant gas is mainly concentrated in the Ostrava district (approximately 90 per cent); the quantity produced in the Kladno district is insignificant. In the Ostrava district, gas is produced in nine coking plants, three of which are metallurgical and six are mining enterprises, which is the reason for the different nature of the use of coking plant gas. For distribution to the public, the gas is supplied under medium pressure, or it is purified and compressed at independent centers for piping over long distances. Large quantities of gas are intended for industrial consumers, to whom the gas is partly supplied in a purified state.

Heating of Brown Coal Briquettes to Produce Strong Char. I — Critical Assessment of Existing Theories. V. R. Megler and G. L. Kennedy. *Fuel 40,* 255 (1961) July (20 pp.)

Studies were made of the use of controlled heating during the carbonization of brown coal briquettes as a means of producing strong char. The object is to analyze the carbonization process and to deduce the time/temperature heating cycle which yields the strongest char for a given heating time. This first paper reviews the limited literature on the design of the theoretical ideal heating cycle and describes an experimental investigation made in Victoria of the one detailed proposal which has been published for conducting such a cycle. This published heating cycle was based on the theory of modifying the rate of heating so as to maintain a constant temperature differential between the surface and the core of the briquette, to even out the shrinkage stress and hence to minimize the fissuring or weakening of the briquette.

Mechanisms of Coal Pyrolysis IV — Variation of the Diamagnetic Susceptibility and Free Radical Concentration with Carbonization Temperature. N. Berkowitz, P. A. Cavell and R. M. Elofson. *Fuel 40,* 279 (1961) July (10 pp.)

Measurements of the diamagnetic component of susceptibility of a series of coal chars, and the free radical concentrations associated with these chars, are reported. The diamagnetic susceptibility is shown to suffer an unexpected transient fall in the range of 1292° to 1382°F, and it is suggested that this may arise from the development of triplet electron states and/or from chemical reactions leading to bond localization (and consequent reduction of the London contribution to χ. The divergence between free radical estimates obtained from e.s.r. and susceptibility data respectively is tentatively associated with π-σ interactions in a Mrozowski model.

Present Trends of Coal Gas Poduction in Belgian Coking Plants. A. Verhaegen. *International Gas Union. IGU/19—61.* 8th International Gas Conference. Stockholm 1961 (10 pp.)

After examining the structure of the Belgian Coking Industry and considering its flexible way of equipping itself with plants of varied origin, it would seem to constitute a free market in which trends do not respond to technical and economic considerations. These trends are investigated by considering not only the existing plants, but also ways for their replacement and the reasons that might influence renewals when plants are to be modified or extended. The conclusion is that progress seems to have consisted in improving those already available, and, on the other hand, that progress has been masked by the constant alteration of the coal treated and of the gas used for heating, the qualities of which have deteriorated.

Thermal Behaviour of Coals at Various Stages of Oxidation. G. Malquori and R. Sersale. *International Gas Union. IGU/30—61.* 8th International Gas Conference. Stockholm 1961 (15 pp.)

Differential thermal and thermogravimetric analysis have been used to determine the thermal behavior of coals of varying rank, previously submitted to oxidation in current air at various temperatures and for controlled periods. The experiments have demonstrated that oxida-

tion modifies profoundly the profile of the thermograms that so usefully integrate the usual measurements of thermo-expansion and thermo-plasticity in this field. The investigations described have been successfully carried out by optical observation of polished sections.

Volumetric Investigations of the Degasification of Coals. K. C. Traenckner. *Erdol u. Kohle 14,* 451 (1961) June (6 pp. German text)

The gases uncondensable at room temperature formed during the degasification of coals are determined exactly by volumetric measurements. These gases show discontinuous curve between 20° and 1000°C. The peaks of degasification are expounded by analysis of the gases from different temperature ranges. Relations are studied between degasification and coking properties with respect to coalification.

Coal Chemicals

Aliphatic Acids from the Oxidation of Coal. G. R. Yohe and J. M. Harris. *Fuel 40,* 289 (1961) July (5 pp.)

Bituminous coals of various ranks were oxidized with alkaline potassium permanganate. Acids, isolated as dilute aqueous solutions by acidification and distillation, were separated and identified by means of paper chromatography. Acetic, propionic, butyric, pentanoic and hexanoic acids in very small quantity were found, and heptanoic acid may have been present in the products from two of the coals. Acids above pentanoic were isolated only from the lower rank coals; none above propionic was definitely isolated from the low-volatile coal.

Coal Gasification

Aspects of the Operation and Development of the Lurgi High Pressure Gasification Plant at Morwell, Australia. B. B. Bennett. *International Gas Union. IGU/12—61.* 8th International Gas Conference. Stockholm 1961 (12 pp.)

The pressure gasification plant at Morwell, Victoria, was the first plant to be built outside Europe for the production of town gas from brown coal by the Lurgi process and its commissioning in 1956 marked the opening of a new era for the gas industry in the state. The plant which produces town gas from brown coal briquettes, is located in the vast brown coal fields of the Latrobe Valley and the gas produced is transmitted by high pressure pipeline to Melbourne, some 90 miles distant, where it is blended with other gases produced from bituminous coal and refinery products. Outputs achieved from individual generators have been higher than originally anticipated but reliability of gasifiers has not been as high as hoped.

Production of Town Gas and Synthesis Gas by the Pressure Gasification of Bituminous Coal. G. Baron. *Erdol u. Kohle 14,* 360 (1961) May (5 pp. German text)

The paper deals in brief with the effects on the thermodynamic conditions as well as on the kinetics of reaction, when coal is gasified in a fixed bed at high pressure, and with the different process techniques used for the gasification of pulverized coal at atmospheric pressure and the gasification of lumpy coal at elevated pressure. New fields of application for pressure gasification are becoming apparent in the United States where large dumps of washery refuse are available for an economic utilization.

Gasification

Estimated Costs of Gasifying Coal in Place: A Study Based on Electrolinking and Hydraulic Fracturing Experiments of the Bureau of Mines. S. Katell and J. H. Faber. *U.S. Bur. Mines Inf. Circ. 8020.* (Washington, D. C.: U.S. Gov't. Print. Off., 1961)

An economic analysis of underground gasification of coal, based on experimental results obtained by the Bureau of Mines, indicates that a gas suitable for use in power plants might be produced for approximately $.62 to $.77/MM Btu. This estimate does not include cost of land purchase. The gasification experiments were conducted in a 3 ft seam of high volatile A bituminous coal. The major factors which can influence a change in operating costs are height of overburden, power costs, thermal efficiency, and the gasification air inlet pressure. Equations show the relationship of these factors to operating costs.

Add Ethylene Production for Profit. J. Chrones and A. R. Johnson. *Petrol. Refiner 40,* 179 (1961) July (4 pp.)

This study indicates that production of ethylene at a refinery location is attractive since it: utilizes existing products; does not pose a marketing problem for either excess existing products or new products; provides a starting point for future byproducts petrochemicals; and provides a means of shifting refinery balances to take advantage of varying market situations.

Method for the Production of Carbon Monoxide From Solid Fuels. C. R. Carkeek and F. E. Guptill, Jr. (assigned to Texaco, Inc.) U.S. 2,987,387 (1961) June 6.

In a process for gasifying carbonaceous fuel (coal, oil shale, wood, etc.) dispersed in steam, an improvement is claimed in which the bulk stream of hydrogen and carbon monoxide formed in the high temperature oxygen generation zone is remixed with a partially gasified feed stream and reacted in a second zone at 1200°F or above for additional gas products. The final bases may be passed to methanation stage before cooling.

Mixed Gas

Measures and Installations Necessary for the Distribution of "Mixed Methane" — Regulating and Safety Devices for Automatic Equipment. K. Sigmund. *International Gas Union. IGU/16—61.* 8th International Gas Conference. Stockholm 1961 (19 pp.)

In the years 1957-58, when several smaller towns in Lower Austria, were connected to the long-distance natural gas system of NIOGAS, a way had to be chosen

for supplying them on the basis of natural gas. A natural gas-air mixture termed "Mixed Methane" was introduced for the following reasons: for systems up to a certain size (serving approximately 10,000 customers) the costs of mixing plants and the modification of gas appliances are lower than those for the erection of a cracking plant with adequate reserves; as no transformation of natural gas takes place, the degree of efficiency is 100%; an automatic mixing plant is used so costs are negligible; the gas is non-toxic since it contains no carbon monoxide; during modification, gas appliances are examined, overhauled, and modernized; appliances modified from town gas (coal gas) to mixed methane will also burn town gas satisfactorily; therefore it was possible to modify as convenient, the existing appliances for mixed methane while town gas is still being distributed; burner jets need not be modified, and it is possible to change back to town gas, or to propane-air mixture.

Oil Gas

Further Survey of the Development of the Use of Petroleum Products in Town Gas Manufacture. *International Gas Union. IGU/9—61.* 8th International Gas Conference. Stockholm 1961 (15 pp)

An endeavor has been made to present the major lines of development in individual countries. The reason for this change in presentation is that the pattern of development is by no means uniform. Each country appears to have its own problems and its own method of developing the use of petroleum to solve these problems. This report is not a comprehensive picture nor does it achieve complete clarification of the several lines of development or the reason for following those lines. It is hoped that its purpose will be achieved if it has brought together information in such a way that representatives from the several countries can add their contribution, thus making the report and the discussion together a comprehensive record of the current situation.

The Production of Town Gas by the Cyclic Otto-CC3P Process. K. Osterloh and E. Walter, *Erdol u. Kohle 14,* 355 (1961) May (5 pp. German text)

Experiences with the large-scale plants established so far have proved the CC3P process is very flexible in its mode of operation. It can be adapted to the requirements of the different firms both from the points of view of desired performance and from variety of feed material.

Ore Reduction

The Blast Furnace. *Chem. Week 89,* 63 (1961) July 8 (5 pp.)

Coke consumption will be reduced from its historic ratio 1600 lb/ton of iron produced to about 1350 lb when fuel oil is used; to 1,200 lb when fuel oil and natural gas are used; and to 1,000 lb when fuel oil, natural gas, and oxygen are combined. Result: although coke is a standard necessity for iron making, it is unlikely that expansions in current capacity will be necessary. This, of course, will limit the capacity for the production of chemicals from coke. The steel industry will not need to expand its blast-furnace capacity for some time, and direct iron ore-reduction processes are likely to find slim pickings as the nation's iron output grows.

Direct Reduction of Iron Oxide by Hydrocarbon. W. K. Lewis. (assigned to Esso Research and Engineering Company) U.S. 2,989,396 (1961) June 20

A process for iron ore reduction is claimed in which the hydrocarbon reducing reagent is preheated by partial oxidation in a separate fluidized zone and then is mixed with more hydrocarbon and injected to the reduction zone. The high temperature (above 1000°C) of partially oxidized gas is reduced by such admixture to 800° to 1000°C, at which the ore reduction will proceed in the second fluidized bed of iron oxide and metallic iron.

New Look Inside Blast Furnaces. *Business Week 53,* (1961) July 22 (2 pp.)

Operation of U.S. Steel Corp.'s experimental stack and construction of full scale furnace should provide first really sophisticated understanding of the iron-smelting process. The industry is deeply involved in exploring a drastic change in iron smelting—the substitution of gaseous or liquid fuel for part of the coke, plus the use of oxygen to enrich the hot blast. For a full understanding of the blast furnace's workings, the interrelationship of hundreds of these variables must be found.

Reduction of Iron Ore by Hydrocabons. G. Tanner. U.S. 2,988,442 (1961) June 13

A process for reducing iron oxides is claimed in which a stream of oxide and metallic iron is advanced in a rotary kiln, while maintaining a heated hydrocarbon gas in counter-current flow and holding temperatures at 500-580°C. The gas is catalytically decomposed by iron to form carbon particles and hydrogen then reacts to form additional iron; so that 40-80% of oxide is reduced. The carbon bearing iron-iron oxide is pelleted and further reduced at 900°C. The kiln of gas may be scrubbed and recycled.

Petrochemicals

Acrylonitrile—Petrochemical Prodigy. D. W. McDonald, K. M. Taylor, and D. M. Brown. *Petrol. Refiner 40,* 145 (1961) July (10 pp.)

Although consumption of acrylonitrile leveled off last year, its long term growth rate should exceed that of the chemical industry as a whole. Acrylonitrile has been one of the outstanding petrochemicals of the past decade. This versatile chemical remained relatively unknown from the time of its discovery in 1893 by Moureu until the need for oil resistant rubbers brought about its commercialization at the beginning of World War II. Since then ever-broadening usage has given rise to a rapidly-expanding acrylonitrile economy. New acrylonitrile processes and plants and new products based on acrylonitrile have been announced with regularity. This review of acrylonitrile shows an up-to-date summary of processes, chemical reactions, and markets in this fast-moving field.

Lean Gases Yield Chemical Feedstocks. T. H. Arnold, Jr., *Chem. Eng. 68,* 118 (1961) July 24 (3 pp)

In an operation unique for its size, the project extracts mixed hydrocarbons in a 450 MMCF/day plant at Cow Island, Vermilion Parish, La.—close to the gas source —and then pipelines the mixture 86 miles to Geismar, La.—near the heart of a growing petrochemical market area—where a 10,000 bbl/day fractionation plant yields ethane, propane, butanes and natural gasoline. Over-all venture cost $13 million, has operated since November. This article focuses on the extraction plant.

Mineral Oil and Natural Gas—Availability as Raw Materials for the Chemical Industry. W. Thies. *Erdol u. Kohle 14,* 489 (1961) June (4 pp. German text)

By means of comprehensive and up-to-date statistical data the question of proved reserves of crude oil, the capacity of refineries, and the crude consumption are treated in detail. The supply of crude oil by means of pipelines gives the possibility to locate refineries in the center of consumption. The natural gas offered in large quantities urges efforts for future utilization. The comparison of prices demonstrates that the calorific price of natural gas from Hassi R'Mel (Sahara) is lower than that of brown coal, which is said to be the cheapest source of energy in Germany.

Process Design

Inventory of New Processes and Technology. *Chem. Eng. 68,* 125 (1961) July 24 (10 pp.)

Eleventh in this magazine's long series of such reviews, this is the second to appear on a new accelerated six-months' schedule. Alternating with these process and technology inventories, and displaced three months from them, are similar tabulations of new process industry plants and facilities. These listings, compiled from a variety of sources, cover only projects that have been made public and have reached a fairly advanced stage of development.

Reformed Gas

Cause and Effect of Raising the Calorific Value of Vienna Town Gas from 4,250 to 4,600 kcal/nm³ (476 to 516 Btu/CF). W. Jorde. *International Gas Union. IGU/14—61.* 8th International Gas Conference. Stockholm 1961 (11 pp.)

A very rapid increase in gas consumption in Vienna has taken place from 1953 onward, its highest peak being that of the cold winter of 1956. The increase is due to the boom and, primarily, to the increased use made of commercial and domestic space heating appliances. With availability of highly efficient sulfur-free natural gas, the Vienna Gas Works have been able to reorganize completely their production of town gas. Between 1952 and 1956, there were initially constructed 10 plants in all, about equally efficient in the production of natural gas/air gas by catalysis. They made it possible to reduce gradually the production of generator gas, which was to cease finally in April, 1958. For increasing the hydrogen content of the town gas, the setting up of cracking installations for natural gas/steam gas was carried out according to local ideas, and, in a further development scheme, four large-scale installations have, up to now, been put into operation. The Vienna Gas Works have been able to meet increasing consumption and, more than this, to adjust coal consumption to the demand for coke. From about 1956 onwards, another difficulty was, however, gradually being felt: at certain peak hours, the carrying capacity of the distribution system was being utilized almost to its maximum limit, and any further stress was sure to result in low pressures that would no longer be tolerated by consumers.

Conversion of Existing Coal Gasification Plants to the Catalytic Reforming of Natural Gas. F. Huber. *International Gas Union. IGU/17—61.* 8th International Gas Conference. Stockholm 1961 (12 pp.)

Since 1955, the significance of natural gas to the Austrian power economy has risen sharply, and in 1959 production was 3,920 MMCF or approximately 7 per cent of the entire Austrian crude energy supply. In order to standardize the supply of gas in Lower Austria, NIOGAS (Niederösterreichische Gasverktriebs-Aktiengesellschaft), which has the sole distribution rights for natural gas in this Province, acquired all five gas works, serving a total of 30,000 consumers. In view of the fact that the town gas production plants were not being used when natural gas was being supplied, some works were adapted for supplying a gas-air mixture with a calorific value of $H_0 = 4{,}600$ kcal/m³ (516 Btu/CF), whereby economic reasons were primarily taken into consideration. In the St. Polten gas works, which were taken over by NIOGAS in the autumn of 1958, town gas ($H_0 = 4{,}000$ kcal/m³) (449 Btu/CF) was produced from coal, with oil carburetion in a double gas generator plant. The prerequisites for conversion from town gas production to natural gas were available, and economic reasons required this to be done as quickly as possible. Conversion was carried out in two stages, First, the plant was adapted for the thermal cracking of methane. This could be done quickly and at very low expense. Thermal efficiency rose by 6 per cent, and the capacity by 12 per cent, simultaneously increasing the calorific value of the town gas to 4,600 kcal/m³ (516 Btu/CF).

Synthesis Gas Production

Production of Carbon Monoxide and Hydrogen. R. W. Chapman, J. C. Ahlborn, and R. M. Dille (assigned to Texaco, Inc.) U. S. 2,987,386 (1961) June 6.

In the process of production of synthesis gas by the partial oxidation process, an improvement is claimed in recovery of carbon from the gas scrubbing zone. This comprises mixing the water-carbon dispersion with a volatile liquid hydrocarbon (benzene, natural gasoline) in a mixing zone and passing the mixture to a vaporization zone, where hydrogen is flashed off leaving the carbon as a floating layer on clarified water. Carbon is readily skimmed off and water recycled.

Water Gas

Carburetted Water Gas Operations in the Australian Gas Light Company. M. V. Gilbert. *International Gas*

Union. IGU/13—61. 8th International Gas Conference. Stockholm 1961 (12 pp.)

The gasmaking plant of the Australian Gas Light Company consists of continuous vertical retort carbonizing plant, carbureted water gas plant and oil gas plant. In addition, two high calorific value gases are purchased and blended; namely, oil gas produced in a Semet-Solvay regenerative reverse-flow oil gas plant at a nearby petrochemical works and LPG from a refinery. Glover-West and Woodall-Duckham installations having a total carbonizing capacity of 2,000 tons per day of good gasmaking coal from the Greta seam in Northern New South Wales. Carbureted water gas of calorific value between 260 and 600 Btu/CF is produced in an installation of 8 Humphreys and Glasgow 2.5 million CF/D and 1 nine million CF/D power gas unit. Their operation is balanced to enable four factors to be met, namely: the demand of gas; the demand for by-products; the continuous control of the interchangeability factor of the mixed gas; and the provision at all times of sufficient gasmaking plant to meet the production requirements in the event of the failure of purchased gases.

8. GAS DISTRIBUTION

Interchangeability

Report of the Committee for the Study of the Interchangeability of Gases. *International Gas Union. IGU/4—61.* 8th International Gas Conference. Stockholm (1961) (59 pp.)

Thermal output, flame stability, and composition quality are specified for trouble free combustion within the range of interchangeability. Definition of the term "interchangeability" is important to the methods of its determination, for standards of gas quality, for specification of test burners, for the composition of test gases, for testing gas appliances, and for determining flame characteristics. The test gases should be made synthetically from not more than a few—preferably three—individual pure gases. Even if practical experience with such test gases by no means suffices to establish that they incorporate all the attributes necessary for trouble-free behavior of appliances in practice, it will be fundamentally necessary to retain the chosen procedure, in spite of the provisional character of the proposals.

The Significance of Gas Quality and Pressure to Distribution and Utilisation Technique. A. van der Linden. *International Gas Union. IGU/34—61.* 8th International Gas Conference. Stockholm 1961 (20 pp.)

For the European Gas Industry, especially on the continent, the last ten years have been marked by a fundamental change in gas supply methods as a result of the introduction of petroleum products. In the near future, and probably for a long time to come, problems presented by diversity of gas quality will dominate the distribution and utilization of gas. Though the attention of gas engineers has been greatly drawn to the technical problems of gas interchangeability, it cannot be said that the more extensive problems of modification of the technique of distribution, and of appliance design, in order to solve the gas interchangeability problem have yet been sufficiently examined.

Network Design

Network Analysis of Gas Distribution Systems. J. C. Challis. *International Gas Union. IGU/11—1961.* 8th International Gas Conference. Stockholm 1961 (7 pp.)

In carrying out measurements on a system of pipes, it must be remembered that pressure gagings, at selected points, may be obtained readily whereas flows in given pipes are largely derived by inference from the number of customers served and their three-monthly meter readings, and local knowledge. As yet no satisfactory portable wide range flow meter has become available, so that the only points at which flows can be measured accurately are at district boosting and storage stations where orifice-plate flow meters are installed permanently. Since the primary input information for this analysis must be a set of self-consistent flows, it follows that the calculation must be based on a set of estimates and a high degree of precision in the final balancing is not warranted. The computation of the balanced flows and pressure drops is iterative. A decision must be made at such a stage that the accuracy of the balance of flows is better than possible direct measurement, with the minimum of processing time.

9. GAS FUEL UTILIZATION AND APPLIANCES

Air Conditioning

Air Conditioning. *Lubrication 47,* 84 (1961) July (12 pp.)

This article discusses the importance and benefits of comfort and industrial air conditioning in the modern world and shows how the proper design, installation, maintenance and lubrication of air conditioning equipment has contributed significantly to the growing acceptance and use of this means of controlling man's indoor environment.

Appliances

Domestic Appliances: A Survey of Sales Points Number 6: Home Laundry. *Gas World 153,* 6 (1961) June 21 (3 pp.)

Annual production figures for washing machines have risen from 93,000 in 1948 to 1,073,000 in 1959, and the monthly average figures in 1960 up to September were about 66,000, but even so there is a market far from saturated yet, as something like three out of every five housewives have still to be persuaded to go in for power washing in their own homes.

Burners

Gas Burner. G. H. Brown (assigned to Whirlpool Corp.) U. S. 2,987,118 (1961) June 6.

A fluid fuel burner is claimed which comprises a porous

plate burner head, a chamber below the plate which is fed by a suction fan, and a flow regulator consisting of facially superposed plates each having registering apertures (to form a rotary shutter). The chamber fan is driven by a motor below the mixing chamber.

Combustion Research

Predicted Burning Times of Solid Particles in an Idealized Dust Flame. R. H. Essenhigh. *J. Inst. Fuel 34,* 239 (1961) June (6 pp.)

Burning times of ideal spherical particles in dust flames have been calculated on the separate assumptions of reaction control: 1) by a diffusion film and 2) by surface chemical reaction. The first assumption is the traditional one, introduced originally by Nusselt and developed by others, which leads to Nusselt's "square law" equation for the burning time (t_b) of a single isolated particle: $t_b = K_D d_o^2$; K_D being the burning constant and d_o the initial particle diameter. The second (chemical) assumption, nearly always previously neglected, leads to a linear law, involving a new burning constant K_c. With both factors simultaneously combined, the two solutions are found to be additive. In flames the burning times are increased owing to the progressive vitiation of the oxygen, and this increase may be allowed for by introducing multiplying factors F_D and F_c, for the two extreme conditions considered separately; these multiplying factors are calculable functions of excess air alone.

The Melchett Lecture for 1960. Radiative Transfer in Combustion Chambers. H. C. Hottel. *J. Inst. Fuel 34,* 220 (1961) June (16 pp. with discussion.)

It is clear that allowance for gas temperature gradients in furnace chambers introduces complications which take the problem out of the category of day to day design calculations on proposed new furnaces. With the advent of machine calculations the systems of simultaneous linear equations which characterize problems of radiative flux are far less formidable than they would have been but a few years ago. The development of sound methods of simple and quick approximation is dependent on the availability of a rigorous method against which to test the short cut. Moreover the growth of interest in plasmas is sure to encourage increasing sophistication in our methods of radiative transport analysis.

Flame Research

Burning Velocity and Reaction Rates in Constant Temperature Non-adiabatic Flames. C. P. Fenimore and G. W. Jones. *Combustion and Flame 5,* 135 (1961) June (6 pp.)

Flames with different fuel/oxygen ratios can be burnt at constant final temperatures on cooled porous burners, the constant temperature being maintained by changing burning velocity so that more heat is abstracted from the flames of greater calorific value. It is not obvious whether the required change of burning velocity is also associated with a change in the rate of fuel consumption and this question has been investigated. In some lean hydrogen or hydrocarbon flames, the rate of fuel consumption has been found to be almost constant in constant temperature flames despite large changes in burning velocity with mixture ratio; and for such flames, the change in burning velocity is accounted for merely by the necessary change in heat abstraction.

Burning Velocity and the Structure of Flames Near Extinction Limits. C. H. Yang. *Combustion and Flame 5,* 163 (1961) June (12 pp.)

Burning velocities and structures of flames are calculated near various extinction limits according to a non-adiabatic flame theory. The theory prescribes burning velocity structure, extinction limits, and includes adiabatic theory as a special case. Numerical results are obtained through the use of analogue computers as illustrated.

The Effect of Flame Configuration on Combustor Performance. C. C. Miesse. *Combustion and Flame 5,* 141 (1961) June (8 pp.)

The effect of flame configuration on combustor performance is analyzed theoretically by assuming that chemical conversion commences when the premixed gaseous propellants pass through the flame surface. Hence, the percentage conversion, which is indicative of performance, can be determined at any point downstream of the flame surface by considering the chemical law of mass action and assuming an integral order of reaction. Integration over the cross section of the combustor then yields the theoretical performance for any selected length of combustor. As could be expected, performance increases as the flame angle increases, and flame configurations resulting from annular flame holders are more efficient than the conventional V-gutter or conical flame holders. Qualitative confirmation of the trends, predicted theoretically, is provided by experimental data obtained from a 2 in. i.d. burner.

Flame Propagation by Non-branching Chain Reactions. J. Adler and D. B. Spalding. *Combustion and Flame 5,* 123 (1961) June (12 pp.)

Steady, one dimensional, laminar flame propagation, proceeding by a non-branching chain reaction with negligible chain breaking is considered. Some exact analytical solutions for the temperature gradient, radical concentration, and flame propagation speed are obtained for particular systems of reaction-rate functions. Approximate methods are developed by means of which the flame propagation speed for any given reaction scheme may be determined.

Studies of Screeching Combustion and Pressurewave, Flamefront Interaction. A. W. Blackman. *Combustion and Flame 5,* 175 (1961) June (16 pp.)

An experimental investigation was undertaken to obtain information leading to criteria which govern the excitation of screeching combustion and to methods for its control. The screech phenomenon appears to result from a coupling between a varying energy release produced by the combustion process and standing waves produced by resonance of the combustion chamber cavity. Tests on small scale combustors showed that screech can be eliminated by properly spacing the flameholders relative to the combustor walls or by adding sufficient damping to the combustion chamber.

Industrial Heating

Some Developments in Industrial Gas Utilization. R. F. Hayman and W. A. Simonds. *International Gas Union. IGU/29—61.* 8th International Gas Conference. Stockholm 1961 (19 pp.)

Development work in industrial gas utilization in Great Britain has always been conditioned by the necessity to design for the most thermally efficient and economic use of a refined fuel. The industrial gas load is now some 32% of the total load and covers the whole field of process heating. Two well equipped research stations combined with development laboratories of Area Boards, are steadily increasing the store of fundamental knowledge on the utilization of gas. Technical information disseminated throughout the Gas Industry by a national organization, ensures the spread of current information to gas engineers, research and trade organizations, and to manufacturers and customers. Descriptions are given of burners suitable for producing the fast moving streams of combustion products often required for convection heating, and a number of applications are described. A refinement is the use of recirculation by jet tubes or with the aid of heat exchangers.

The Mixture Reaction in Flames for Industrial Heating Appliances. R. Gunther. *International Gas Union. IGU/36—61.* 8th International Gas Conference. Stockholm 1961 (15 pp.)

In many industrial furnaces and other appliances, thermal efficiency is low, but can be improved when heat transfer from the combustion gases is made as high as possible. Many engineers and scientists are working in this field. The results of their efforts are to be found in modern soaking pits with circular flow, stoves with heat transfer by convection, and gas radiators for heating large rooms. In small appliances and with fuels that burn with a non-luminous flame, high radiation from the combustion gases cannot be expected. Efforts are therefore directed to improving heat transfer by convection, e.g., by employing high velocities of furnace gases or by using transmitting links between furnace gas and the substance to be heated. In large furnaces, the aim is to increase the radiation of the flames, for example, by the cracking of hydrocarbons, or to ensure efficient heat transfer by suitable adjustment of the shape and position of the flame. In any case, the task is to transfer heat in the desired and necessary quantity at a suitable temperature and with the desired local distribution.

Refrigeration

Centralized Refrigeration Appears as a Public Utility Service. *Power 105,* 71 (1961) July (3 pp.)

As early as 1940, centralized air conditioning was visualized as a public utility service. Some 21 years later, the dream is coming of age in Hartford, Conn., as the Hartford Gas Co. prepares to put a $3-million central plant into operation in 1962. Today utilities are taking a close look at cooling as a promising market for growth. The projected plant will send heating steam and chilled water to control the climate of all buildings in the Plaza and some of the nearby buildings. In its own first stage of growth the plant will have an installed capacity of 150,000 lb steam per hr and 650 tons of refrigeration.

Space Heating

Gas Heating in the Construction of Houses. G. Duwel, W. Stehn, and F. Awe. *International Gas Union. IGU/38—61.* 8th International Gas Conference. Stockholm 1961 (19 pp.)

In industrial countries, 60 to 70 per cent of primary energy consumed is required for heating purposes. Of this portion, about 40 per cent is for domestic space heating. Here is a large field to be gained for heating by gas. New methods of heating by gas are creating the preliminary conditions for canvassing the sale of gas for space heating, from which an important opportunity to extend the market for gas and to increase the turnover of the gas utility will arise. Examples are given of gas-fired separate appliances and of central and block heating units actually installed, and possibilities of applying gas heating and the consumption data obtained are illustrated. Hints are given concerning the necessity to develop further new installation methods for the incorporation of units and exhaust systems.

Householding Customers Up 1.1 Million. *A.G.A. Monthly 43,* 14 (1961) July-August (4 pp.)

Residential heating customers of gas utilities in the United States totalled 21,352,000 at the end of 1960, compared to slightly under 20.2 million at the end of 1959. The year's gain of 1,171,000 represents an increase of 5.8 per cent in the number of residential customers using gas for househeating and raises the proportion of such customers to 69 per cent of all residential customers of gas utilities, compared to 67 per cent at the end of the preceding year.

Ventilation

Second Investigation on Unconventional Flues. *International Gas Union. IGU/8—61.* 8th International Gas Conference. Stockholm 1961 (15 pp.)

Information on branched flues was sought only in regard to the vending of gas appliances, and progress with this system is reported from a number of countries. In France and Belgium the system is officially permitted by regulation and in a number of other countries is not specifically prohibited. Generally the basic designs of the system are found to be similar in different countries, and all specify good termination as a first requirement, with a minimum height of about 20 ft above the top appliance. British experiences are described with an installation serving gas fires in which recording instruments showed that occurrence of downdraught was negligible. Tests on a further installation confirmed the importance of a good terminal position.

Water Heaters

Continuous Flow Coil Type Heater. W. Reitz and R. Lehnartz (assigned to Joh. Vaillant K-G.) U. S. 2,987,060 (1961) June 6.

A water heater is claimed which includes improvements in mounting of the heating coil. The heating coil is

wrapped around a sheet metal cylinder with a heavier cross tube at the top which forms a shoulder holding against two lateral brackets. The hot and cold ends of water tube are brought downward and pass through horizontal brackets fastened to the rear wall of the casing. The tube ends are brazed to threaded nuts which draw the tube coil tightly into place and support the coil assembly.

Non-Integral and Horizontal Domestic Gas Water Heaters. J. C. Griffiths. *A.G.A. Res. Bull. 87,* (1961) (79 pp.); June Catalog No. 142/DR. Price $3.00

A non-integral water heater, consisting of heat exchanger and remotely located storage vessel, appears to be one feasible way of removing the water heater from free floor space in the home. Information has been developed on the performance characteristics of this type of built-in hot water service with a wide variety of piping connections. Two prototype, non-integral water heaters were constructed. One of these was a 50,000 Btu/hr, 25 gal. table top unit. This unit performed satisfactorily, except that it would require modification of its built-in draft hood to satisfy current draft hood performance requirements. The other 30 gal., 45,000 Btu/hr unit was located below a built-in oven with its storage vessel placed above the oven. Four designs of small, horizontal water heaters which could be mounted from ceilings or in attic crawl spaces were also considered. None gave completely satisfactory performance.

Water Heater. G. H. Huber (assigned to Huber Heating Co., Inc.) U. S. 2,987,061 (1961) June 6.

A water heater is claimed comprised of a U-shaped heat exchange chamber. The chamber consists of a first and second column, both extending into a lower sump chamber. A gas burner throws a flame downward from the top of the first column, and hot gases are exhausted from the top of the second column by a fan, while a thin film of water runs down the wall of each column. Thus a long path of heat exchange is afforded by the wet column surfaces.

Furnace

Combined Melting Hearth and Gas Reformer Apparatus. Frank W. Luerssen (assigned to Inland Steel Company) U. S. 2,989,297 (1961) June 20.

A combined melting hearth and gas reforming furnace is claimed, in which reduced iron ore is fed to a first chamber where it is melted by a coal-oxygen flame. The high CO_2 of gases passes through a restricted channel to an adjacent reforming chamber where excess fuel and oxygen is injected. The CO_2 is reduced to CO and is removed for treatment and further use in ore reduction.

10. EQUIPMENT AND INSTRUMENTATION

Flowmeter

True Mass Flowmeter. R. B. Rowley. *Petroleum 24,* 211 (1961) June (4 pp.)

Many modern processes require the accurate measurement and control of fluids and as in all other realms of measurement, there is an ever increasing demand for more accurate and more versatile flow, measuring instruments. The true mass flowmeter, although developed for, and at present applied to aircraft requirements, can well meet the needs of many industrial applications where the handling of fluids requires such accurate flow measurement.

Compressors

Air Compressor HP, Operating Costs. S. Katell and P. Wellman. *Petrol. Refiner 40,* 210 (1961) July (3 pp.)

A previous study presented the horsepower requirements and operating costs for centrifugal compressors handling 20,000 to 60,000 SCFM of air when the discharge pressure varies from 50 to 120 psig. Suction conditions were assumed to be 14.7 psig and 68° F (ASME code). Product air discharge temperature was established as 100° F.

Pumps

Centrifugal Pumps for Pipe Line Service. Carlo Bartolero and Ernest E. Lindros. *Pipeline News 33,* 17 (1961) July (4 pp.)

Capacities, heads, and in many applications speeds have all increased in the past 25 years. From pumping water and hydrocarbons over a relatively narrow range of temperatures, the industry is now asked to supply equipment to handle almost every liquid from liquid hydrogen, at minus 420° F and weighing less than 4.4 lb per cu ft, to mercury weighing about 850 lb per cu ft, and liquid metals such as lead, sodium, sodium-potassium, bismuth, and magnesium at temperatures as high as 1500° F. Pumps are being supplied for suction pressures in excess of 5000 psi and others for differential pressures, operating in series, of over 6500 psi.

Reactors

Reactions in a Fluidized Coke Bed with Self-Resistive Heating. H. S. Johnson. *Can. J. Chem. Eng. 39,* 145 (1961) June (3 pp.)

When electrodes are inserted in a fluidized bed of conductive coke particles, an electric current can be passed with sufficient power to raise the bed to a high temperature. This device becomes a chemical reactor when the fluidizing gas is appropriately chosen. The reaction conditions which obtain in such a reactor are sometimes of especial value in producing favorable yields in chemical reactions. The design and operating characteristics of laboratory scale units are described.

Steam Generation

Steam in Gas Production. *International Gas Union. IGU/23—61.* 8th International Gas Conference. Stockholm 1961 (8 pp.)

In the field of gas production may be found an important evolution of steam utilization by its increased use as a raw material (re-forming) and by the diminish-

ing of old traditional practices such as using steam for the production of electricity and for the heating. Waste heat boilers play a large part in steam production, superheating being common when recuperation involves flue or other gases that are free of abrasive particles. Major gas undertakings no longer construct coke breezefired steam producers, but those still in existence are kept in service. In the case of smaller plants, old installations are sometimes modernized by using fuel oil for firing. Most of the newer installations comprise quick-starting fuel-oil boilers which serve to balance and replace recuperative boilers at the starting. Furthermore, increasingly more frequent utilization of auxiliary burners on recuperative boilers can be observed, providing steam production with a certain flexibility.

11. MATERIALS OF CONSTRUCTION, AND CORROSION

Cathodic Protection

Deep Well Ground Beds for Cathodic Protection of Multiple Lines in Highly Congested Industrial Areas. *Corrosion 17,* 323t (1961) July (2 pp.)

An account is given of the successful installation of deep well type, high silicon iron anodes in a highly congested industrial area. Multiple lines were cathodically protected in this way despite the presence of nearby gas and water mains, power line grounds, and underground telephone cables. A special control system was designed for installation at each rectifier involving use of switches, ammeters, rheostats, non-reversing current diodes, and surge protectors.

Gas Company Uses Cathodic Protection Training Program. C. Gibson. *Corrosion 17,* 14 (1961) July (3 pp.)

Describes one gas company's experience in planning and setting up a training course for its personnel in cathodic protection installation. Explains importance of planning a training course to achieve desired results. Outlines principles of training, methods of instruction used, subject matter of the course, and methods of evaluating course. Presents 51-question test on cathodic protection and corrosion control, in general, which was given to company personnel to determine need for training and also used after the training course to evaluate how much knowledge had been acquired by participants.

Results of an International Inquiry on the Cathodic Protection of Gas Pipelines. *International Gas Union. IGU/6—61.* 8th International Gas Conference. Stockholm 1961 (16 pp.)

The inquiry performed and evaluated for the International Gas Union by the DVGW-Committee for the study of Protection of Pipes Against Corrosion showed that by the middle of 1959 at least 50,000 km (31,070 miles) of gas mains with a surface of 90,000,000 sq m (22,230 acres) had been cathodically protected throughout the world. The total intensity of cathodic protective currents of at least 110,000 amp is equivalent to a direct saving of corrosion losses of 1000 tons of steel/yr. If this were to be spread equally over the whole surface, it would be practically harmless, but since corrosion in most cases creates holes, a few grams loss of iron often suffices to cause leakages, and a few kilograms lost suffice to render a pipeline absolutely useless for its original purpose, i. e. as a means of transportation. In order to gain a correct impression of the effect of the current intensity it should be kept in mind, that it provides the means to protect 5,000,000 tons of steel from corrosion.

Coatings

Corrosion: A Laboratory Investigation of the Resistance of Asphalt and Coal Tar Coatings to Soil Stresses. P. R. Butterfield. *Pipeline News 33,* 35 (1961) July (2 pp.)

Resistance of a coating to deformation by soil stresses is important when considering a material for use as an underground pipeline coating. The degree of importance may depend upon the environment where the line is located.

Functional Finishes for Metals. H. L. Kee. *Prod. Eng. 32,* 39 (1961) July 17 (12 pp.)

A part usually must withstand more abuse at its surface than internally. This is why the surface is important for more than decorative reasons. It explains why one of the most economical design approaches is to make the part from one base material and then do something to its surface—either alter it in some advantageous way or provide it with a functional coating of some other material. Such finishes provide the designer with several functions that may be needed. Among these are: corrosion, wear, heat, and oxidation resistance; electrical and magnetic properties; soldering aid; lubrication; and reflectivity. Types and amount of cleaning and finishing necessary for the various basic surface treatment costs are given on a comparable basis.

Process Variables in Plasma-Jet Spraying. D. R. Mash, N. E. Weare, and D. L. Walker. *J. Metals 13,* 473 (1961) July (6 pp.)

The introduction of commercial plasma-jet equipment has rapidly advanced the technology of spray coating. The purpose of this paper is to review briefly some of the experimental data collected during several past investigations with the hope of stimulating additional experimental and theoretical research efforts in this field. As a result of such work, plasma-jet spraying technology can be expected to grow steadily on a sound scientific basis, rather than resting on pure empiricism.

Construction Materials

Corrosion and Segregation Phenomena on Highly Heat Resistant High Grade Steels for the Petrochemical and Oil Processing Industries. P. H. Huppertz. *Erdol u. Kohle 14,* 371 (1961) June (14 pp. German text.)

After discussing fundamental aspects of highly heat resistant steels, especially as materials for the pipe stills in the petrochemical industry, high temperature corrosion, including the attack by sulfur compounds, by the ash

of fuels, or welding cinder which has not been removed must also be considered. The influence of temperature on heat resistant Cr- and Cr-Ni steels is demonstrated, and some experiences on the 475°C embrittlement of ferritic chrome steels, the sigma phase, and segregations of chromic carbide are given.

Iron, Carbon Steel, and Alloy Steel. H. S. Link and R. J. Schmitt. *Ind. Eng. Chem. 53,* 590 (1961) July (6 pp.)

Improved compositions and more economical processing procedures have lowered product costs. Marked weight reduction is now possible in many structures by use of higher strength iron and steel. Carbon and low alloy steels may be practical for boiling water nuclear reactor plants. During 1959 and 1960, a major effort of the iron and steel industry has been toward lower costs of ferrous products. In the design of many structures, higher allowable stresses are used in take full advantage of the weight saving potential of high-strength steels and constructional alloy steels. Increased interest in higher yield-strength steels led to lower cost versions, so that even greater economies are now possible in certain applications. Savings are also made by using improved carbon-steel products and iron castings for many items that previously required more expensive steels. Porcelain-enameling steels that do not require a ground coat are examples.

Corrosion

The Casing Inspection Tool—An Instrument for the *In-Situ* Detection of External Casing Corrosion in Oil Wells. T. R. Schmidt. *Corrosion 17,* 329t (1961) July (5 pp.)

A surface recording, down hole instrument for the detection of external corrosion in oil wells is described. The tool is a non-contacting, eddy-current instrument which measures and records casing wall thickness. Equations are presented which are useful in describing the tool's action. Examples of laboratory and down hole logs are shown demonstrating the tool's response to general thinning, pits, holes, collars, etc. Results of a number of down hole runs representing some 40,000 ft of well logged are discussed.

Continuous Corrosion Monitoring. E. S. Troscinski, A. S. Couper, and A. Dravnieks. *Mech. Eng. 83,* 47 (1961) July (5 pp.)

There is a definite need for a reliable method which will not only detect but also monitor corrosion continuously and aid in the rapid selection of the most suitable construction materials. Each of the several methods used to monitor corrosion to obtain reliable corrosion data offers advantages and disadvantages. The corrosion probe, the most sensitive method for detecting and measuring corrosion, can measure losses as small as a few millionths of an inch. Such accuracy permits rapid determination of corrosion rates. Probes can be installed at any point in a unit, and measurements can be made without interfering with the normal operation of the unit. Continuous monitoring is possible.

Effect of Mineral Impurities in Water on the Corrosion of Aluminum and Steel. L. C. Rowe and M. S. Walker. *Corrosion 17,* 353t (1961) July (4 pp.)

The effect of several common mineral constituents in water was determined. These included such impurities as chloride, sulfate, bicarbonate, carbonate, calcium, magnesium, and silicate. Of this group, it was found that chloride and sulfate are most detrimental to steel. No single impurity affects the corrosion of aluminum to the degree that mixed impurities do. A solution containing soluble salts of copper, chloride, and bicarbonate has an accelerating effect on the corrosion rate of aluminum. Pitting depends upon impurity concentration and temperature.

Pitting Corrosion by Water Flood Brines. P. J. Raifsnider and A. Wachter. *Corrosion 17,* 325t (1961) July (4 pp.)

Serious pitting corrosion has been experienced in several closed system water floods in secondary recovery operation in oil fields. A laboratory test method was developed which rapidly reveals pitting tendencies in samples of water flood brines. Using this method, it was shown that trace amounts of oxygen are responsible for the pitting in these water floods, and that corrosion can be prevented by adding an oxygen scavenger such as sodium sulfite. Relatively low concentrations of corrosion inhibitor are adequate when oxygen is completely removed. In addition, a low cost, rapid response test probe for field use has been developed to aid in monitoring mitigation treatments.

Stainless Steels and Other Ferrous Alloys. W. A. Luce and J. H. Peacock. *Ind. Eng. Chem. 53,* 586 (1961) July (4 pp.)

Stress corrosion and intergranular corrosion account for significant portion of research. High temperature mechanical properties are being emphasized, and the demand for materials to satisfy specialized conditions is broadening the scope of stainless steels. The demand for materials to meet a specific requirement for a particular application in various industries emphasizes the importance of stainless steels. Slight modifications of existing alloys, are permitting stainless steels to be applied in a wide range of conditions. From a temperature aspect only, conditions may vary from very low subzero temperatures to those in excess of 2000° F. Normal service conditions encountered in handling process solutions in the temperature range of 100° to 400° F are also of considerable importance. Such services are of utmost concern because modified and newly developed solutions are, in many cases, much more corrosive than those previously used, thus requiring more corrosion-resistant materials. (66 references are cited.)

Ore Reduction

Refining of Ores with Hydrocarbon Gases. Richard W. Hyde (assigned to Arthur D. Little, Inc.). U. S. 2,990,-269 (1961) June 27.

A reduction process for iron oxides is claimed, in which a hydrocarbon gas (methane) is preheated to 500-650°C burning with 24.33% theoretical air, and the combustion products are injected into a fluidized partly reduced bed. Metallic iron in this bed reforms the remaining CH_4 to CO and H_2, which passes up the retort into a "reducing" fluid-bed. Here the preheated iron ore is

partially (75-80%) converted to iron. The 3 beds are superimposed to provide counterflow of the reducible ore and the reducing gases. Some gas from the reducing bed may be burned to preheat and pre-reduce the incoming ore.

12. ANALYTICAL METHODS AND TESTS

Hydrogen Sulfide

The Analytical Determination of Hydrogen Sulfide and Sulfur Dioxide Side by Side by Means of Test Tubes. G. Heuschkel. *Erdol u. Kohle 14,* 467 (1961) Aug. (2 pp. German text.)

This article deals with the possibility of the analytical determination by means of test tubes of hydrogen sulfide and sulfur dioxide in waste gases from a Claus unit, and gives an account of the accuracy obtainable. It also describes the fabrication of suitable filling materials.

Analytical Instruments

Measure Boiling Points Continuously. M. W. Luther and C. K. Donnell. *Petrol. Refiner 40,* 169 (1961) July (6 pp.) also *Oil Gas J. 59,* 69 (1961) July 17 (7 pp.)

Six process stream analyzers were installed on a combination distillation unit to monitor its performance. The analyzers were tested over a two-month period by substituting standard samples in place of the plant streams normally monitored. It was determined that three analyzers were outstanding with 90% of their readings deviating from the average by not over 2° F. With only one exception, all of the analyzers gave more consistent results than the laboratory distillation apparatus.

Chromatography

A Stationary Phase for Gas-Liquid Chromatography. W. G. Finnegan and S. R. Smith. *J. Chromatog. 5,* 461 (1961) June (5 pp.)

Data are presented to show the versatility of 1-methyl-5-(2-methoxyethyl)-tetrazole as a stationary phase for the gas-liquid partition chromatographic separations of mixtures of hydrogen, nitrogen, carbon monoxide, C_2—C_6 cyclic and acyclic alkanes, alkenes, alkadienes, and benzene. Its complexing properties and strongly polar nature assist markedly in the separation of a series of cyclic C_6-hydrocarbons of increasing unsaturation having similar boiling points and other C_5 and C_6 straight-chain compounds. Previous clean separation of these compounds by gas chromatography has not been reported.

Determination of Mixed Lead Alkyls in Gasoline by Combined Gas Chromatographic and Spectrophotometric Techniques. W. W. Parker, G. Z. Smith, and R. L. Hudson. *Anal. Chem. 33,* 1170 (1961) Aug. (2 pp.)

Gas chromatography technique is combined with spectrophotometry for the rapid determination of mixed lead alkyls in gasoline. The lead alkyls are separated by gas chromatography and reacted with dithizone reagent. The resulting complex is measured at 520 μ.

Determination of Small Amounts of n-Paraffins by Molecular Sieve—Gas Chromatography. F. T. Eggersten and S. Groennings. *Anal. Chem. 33,* 1147 (1961) Aug. (4 pp.)

A gas chromatographic procedure using selective absorption on a molecular sieve determines normal paraffins in light petroleum. The sample is passed through the columns and then converted to carbon dioxide in a combustion tube and a chromatogram obtained. Normal and non-normal (iso- and cyclo-) paraffins are determined.

Determination of Volatile Hydrocarbons in Aqueous Emulsions and Latexes by Gas Chromatography. F. M. Nelsen, F. T. Eggertsen, and J. J. Holst. *Anal. Chem. 33,* 1150 (1961) Aug. (3 pp.)

A rapid and accurate gas chromatographic procedure is used for determining volatile hydrocarbons in a polymer-water system or latex. The sample is vaporized and the volatile component oxidized to carbon dioxide and water. After the water is removed the carbon dioxide is measured by a thermal conductivity detector.

Low Temperature Gas Chromatography. R. S. Porter and J. F. Johnson. *Anal. Chem. 33,* 1152 (1961) Aug. (4 pp.)

A low temperature gas chromatographic procedure is developed for the separation of gas mixtures. Separation is performed at −78°C over n-heptane, n-octane, and acetone as well as over support material, crushed brick, and glass beads. Analytical application is evaluated for gases such as hydrogen, carbon monoxide, hydrocarbons, oxygen and others.

Electron Microscopy

Particle Size Distribution Measurements below Five Microns. R. R. Irani nad E. F. Kaelble. *Anal. Chem. 33,* 1168 (1961) Aug. (3 pp.)

Centrifugal sedimentation and electron microscopy are compared for determining the particle-size distribution of calcium phosphate and silica below 1 micron, the electron microscopy technique is more practical and requires less time.

Research Techniques

Thermal Analysis. A Critique. P. D. Garn. *Anal. Chem. 33,* 1247 (1961) Aug. (5 pp.)

Examination of techniques and consideration of special factors are given for thermal analysis. It is advantageous to have a technique which permits direct correlation of thermogravimetric and differential thermal analysis data.

13. BASIC SCIENCE

Adsorption

Effect of Chemisorbed Hydrogen on the Magnetization of Nickel. R. E. Dietz and P. W. Selwood. *Chem. Phys. 35,* 270 (1961) July (12 pp.)

The effect of chemisorbed hydrogen on the saturation

magnetization of nickel was investigated on fine particles of nickel. For certain preparations the saturation moment of the nickel was within 1 of 2% of that of massive nickel; this is considered evidence that the surfaces of the nickel in these samples were substantially free from chemisorbed impurities, and that the electronic state of the nickel was identical to that of massive nickel. For these preparations, hydrogen decreases the saturation moment of the nickel by about 0.7 Bohr magneton per average atom of hydrogen adsorbed. This effect appears independent of temperature up to 300°K (the highest temperature investigated) and of surface coverage over nearly the entire range.

Diffusion

Diffusional Transport of Atomic Hydrogen Through Molecular Hydrogen at Elevated Temperatures. H. Wise. *J. Chem. Phys. 34,* 2139 (1961) June (3 pp.)

Changes in transport properties of a gas mixture of atomic and molecular hydrogen were measured in a temperature range from 300° to 700°K. The steady state distribution of atoms diffusing from a source towards a catalytically active surface was determined in a cylinder of finite length. The experimental parameter of interest is the diffusion Reynolds number which contains the ratio of interdiffusion coefficient to recombination coefficient. If the catalytic activity of the surface is known, one may relate the atom concentration gradient to the diffusion coefficient. In the temperature region studied the change in the binary diffusion coefficient for the system H, H_2 was evaluated. Based on the results obtained, the intermolecular force fields applicable to the atom-molecule encounters were examined.

Fluid Flow

Fluid Friction and Heat Transfer in Cylindrical Pipes: Relationship between Lumped and Distributed Parameters. J. C. Smith. *Can. J. Chem. Eng. 39,* 106 (1961) June (7 pp.)

The characteristic lumped parameters used in problems of heat transfer and fluid friction are overall or average fluxes of heat energy or momentum, arbitrarily defined as described in this paper. Common dimensionless groups, such as f, N_{Re} N_{St} and others are ratios of these energy or momentum fluxes. Such dimensionless groups, since they are ratios of lumped parameters, are themselves lumped parameters. In their definition, therefore, several assumptions regarding the distributions of velocity and temperature are implicit. When these assumptions are not valid, correction factors such as diffusivity ratios or length-to-length ratios are needed to allow for deviations from the distributions used for reference.

Fundamental Aspects of Solids-Gas Flow. Pt. VI. Multiparticle Behavior in Turbulent Fluids. L. B. Torobin and W. H. Gauvin. *Can. J. Chem. Eng. 39,* 113 (1961) June (8 pp.)

At Reynolds numbers approaching unity the particles in a solids-gas system acquire a turbulent motion in response to the turbulence of the ambient fluid. This regime is of particular importance and a discussion of recent theoretical and experimental attempts to describe it is presented. The reaction of the fluid phase to the presence of the particles is equally important. The extent to which the mean and turbulent properties of the fluid motion are affected by the presence of the solids phase is governed by the particle concentration and the fluid and solids Reynolds numbers.

Heat Transfer

Heat Transfer to High-Quality Steam-Water Mixtures Flowing in a Horizontal Rectangular Duct. *Can. J. Chem. Eng. 39,* 99 (1961) June (7 pp.)

Heat transfer and pressure drop were investigated for steam-water mixtures flowing in an electrically heated horizontal duct of rectangular cross-section. The investigation was primarily concerned with the region of high vapor fractions and mass flow rates, where two-phase convention-controlled heat transfer predominated. The experimental data were found to be in good agreement with those of other studies in which circular tubes were used.

Fluid-to-Particle Heat Transfer in Fluidized Beds. J. F. Frantz. *Chem. Eng. Progress 57,* 35 (1961) July (8 pp.)

Dimensional analysis of the variables affecting fluid-to-particle heat transfer results in an equation form for correlating fluid-to-particle heat transfer coefficients. From 14 investigators, it is shown that only 6 produced consistent results. The 6 consistent sets of data gave 2 generalized equations, one for the true coefficients and the other for apparent coefficients. The influence of the particle shape and void fraction has not yet been determined. Generalized equations for fluid-to-particle heat transfer have been proposed. Further work is needed in gas-fluidized beds to study the influence of the Prandtl number. Specific studies on the effect of shape factor and void fraction are desirable.

A Review of Heat Transfer Literature 1960, Pt. I. E. R. G. Eckert, T. F. Irvine, Jr., E. M. Sparrow, and W. E. Ibele. *Mech. Eng. 83,* 34 (1961) July (9 pp.)

New theories are being evolved and old ones checked and rechecked. Analytical and experimental studies are the prerequisites to the calculation of heat transfer. This review introduces a new section discussing thermodynamic and transport properties. A significant increase in the number of papers dealing with radiation becomes immediately apparent by comparison with the number contained in the 1959 review.

Hydrates

Natural Gas Hydrates at Pressures to 10,000 PSIA. H. O. McLeod, Jr. and J. M. Campbell. *J. Petrol. Tech. 13,* 590 (1961) June (5 pp.)

This paper presents the results of the data obtained in the first stage of a long-range study at high pressures of the system, vapor-hydrate-water rich liquid-hydrocarbon rich liquid. The data presented are for the three phase systems in which no hydrocarbon liquid exists. Tests were performed on 10 gases at pressures from 1,000 to

10,000 psia. One of these was substantially pure methane, and the remainder were binary mixtures of methane with ethane, propane, isobutane, and normal butane.

Ignition

Ignition of Gases by Electrically Heated Wires. L. E. Ashman and A. Buchler. *Combustion and Flame 5,* 113 (1961) June (9 pp.)

Experimental studies have been conducted on the ignition of gases with constant temperature wire ignition sources. The wire is heated to the desired temperature in a period of microseconds by means of a condenser discharge. Thereafter, its temperature is maintained constant by a unique feedback control circuit, incorporating a photomultiplier tube that monitors radiations from the center of the wire. With this apparatus experimental studies of ignition temperatures and ignition delay have been made on stoichiometric methane-air and hydrogen-air mixtures. With the methane-air mixture, an exothermic reaction occurs during the pre-ignition period. This pre-ignition reaction occurs at a velocity and for a period of time that depend on the temperature of the wire. Near the end of this pre-ignition period, the reaction accelerates to a more rapidly propagating flame front. In the hydrogen-air mixture, no measurable reaction occurs during the pre-ignition period.

Inflammability

On Inflammability Ranges of Formaldehyde and Carburetted Air Under Reduced Pressure. M. P. Brunold, R. Delbourgo, and P. Laffitte. *Combustion and Flame 5,* 191 (1961) June (4 pp.)

The inflammability regions of formaldehyde and air with small amounts of hydrocarbon (2.4 to 5.4%) have been studied. The addition of propane or methane leads to a strong inhibition of the formaldehyde range together with the appearance of a second lobe structure of the curves described with pseudo cool flame characteristics. The influence is continuous and leads to a well laid out family of curves. Whenever hydrocarbon is present in the mixture, even in trace amounts, the properties of the flames encountered are those of the hydrocarbon and not those of the formaldehyde mixture.

Kinetics

The Hydrogen Isotope Effect in the Pyrolysis of Cyclopropane. A. T. Blades. *Can. J. Chem. 39,* 1401 (1961) July (8 pp.)

The hydrogen isotope effect in the thermal rearrangement of cyclopropane has been determined by the copyrolysis of cyclopropane and cyclopropane-d_6. The isotope effect in the temperature range 407 to 514°C and at pressures of about 60 cm Hg may be expressed by

$$k_H/k_D = 0.82 \exp(1300/RT).$$

The isotope effect is pressure dependent, decreasing from 1.98 at 76 cm Hg to 1.35 at 0.0178 cm Hg at 482°C. The isotope effect and its temperature and pressure dependence are discussed in relation to the mechanism. The conclusion is reached that though trimethylene may be formed as an intermediate, the isotope effect is consistent only with an activated complex where a hydrogen atom is weakly bonded both to its original and ultimate carbon atoms, a situation which might also lead directly to propylene. A similar argument is presented to account for the previously described isotope effect in the decomposition of cyclobutane.

Mass Velocity

High Velocity Combustion Applied to Chemical Processing. Part I. L. C. Peskin. *Chem. Eng. Progress 57,* 94 (1961) July (4 pp.)

High velocity combustion consists basically of carrying out an exothermic reaction between the fuel, usually a common hydrocarbon, and the oxidant, ordinarily air in which the mass velocity upstream of the burning zone is high enough to provide stable burning at release rates in the millions of Btu/CF/hr. A burner design has been achieved which produces controlled recirculation of very hot products of combustion from the combustion chamber of the burner in such a manner that the heat from these gases is capable of entirely vaporizing a distillate type of oil or other fuel that can be evaporated.

Ore Reduction

Reducing Gases by Partial Oxidation of Hydrocarbons. S. C. Singer, Jr. and L. W. ter Haar. *Chem. Eng. Progress 57,* 68 (1961) July (7 pp.)

Ore reduction techniques will undergo marked changes within the next decade in order to improve operating efficiency, reduce fuel consumption, increase ore handling capacity, and reduce invested plant capital. These are changes that will be of far reaching significance; changes in which the chemical engineer will play a key role. An idea of the importance of this movement may be gained from the large amount of plant scale work presently in progress to inject gaseous and liquid fuels directly into the blast furnace. According to reports, these efforts are effecting economies of 15 to 20% in coke requirements and increasing equipment capacity by a similar amount.

Particle Size

The Adhesion and Cohesion of Fine Particles. B. B. Morfan. *BCURA Monthly Bull. 25,* 125 (1961) April (13 pp.)

Few generalizations can be drawn from the reported observations on particle cohesion and adhesion. The various tests all seem to measure related properties and the two tests most readily interpreted would seem to be, for cohesion, the splitting of a powder bed and, for adhesion, the sliding of powder over an inclined plate. Both cohesion and adhesion increase with particle fineness, but no simple relation of general applicability has been found. A rise in humidity also results generally in an increase in stickiness, especially at relative humidities exceeding 80%: presumably this would occur with other vapors also. The existence of a number of mechanisms of attraction sufficient to explain the observed phenomena is known. Theoretical predictions concerning

the long-range forces at fairly large distances of separation have been confirmed using microscopic bodies.

Permeability

Effect of Methyltrichlorosilane on Permeability on Sandstone Cores to Gas and Water. W. L. Schmidt and C. J. Walker. *U. S. Bur. Mines Rept. Invest. 5836* (Washington, D. C.: U. S. Dept. of the Interior, Bureau of Mines, 1961; 16 pp.)

The effect of a water-repellent film of sandstone cores on the effective permeability—saturation relationship was investigated as part of a cooperative research program between the Bureau of Mines and the American Gas Association. The repellent film was formed by the reaction of methyltrichlorosilane with the connate water in the core. The primary purpose of this study was to determine the feasibility of using silane to retard the influx of water into natural-gas storage wells and to determine the necessary requirements for achieving this result. Of thirteen cores treated with silane, 6 showed an increase in effective permeability to gas. However, only one of the six showed a decrease in the effective permeability to water, and the other five showed increases. The remaining seven cores showed a decrease in effective permeability to gas. Four of these seven cores showed increases in the effective permeability to water, and three showed decreases.

Thermal Conductivities of Porous Rocks Filled with Stagnant Fluid. D. Kunii and J. M. Smith. *J. Soc. Petrol. Eng. 1,* 37 (1961) March (6 pp.)

Effective thermal conductivities of sandstones filled with stagnant fluids were measured using a steady-state technique. Data were obtained for seven sandstone samples, taken from four different locations and ranging in permeability from 18 to 590 md. The measurements with gases (helium, nitrogen, air, and carbon dioxide) covered a pressure range from 0.039 psia to 400 psig. Data were taken for four liquids—n-heptane, methyl alcohol, 79.8 weight per cent glycerol-water solution and pure water at atmospheric pressure.

Radioactivity Applications

The Radiation Chemistry of Bituminous Coals in Various Atmospheres. A. Weinstein, F. Rusinko, Jr., and P. L. Walker, Jr. *Fuel 40,* 241 (1961) July (14 pp.)

The radiolysis of selected bituminous coals in vacuo and the reactions of the coals with oxygen, air, and nitrogen in the presence of gamma and fast neutron radiation were studied. The only detectable products of radiolysis of the coals at 3.5×10^8 rads dosage were hydrogen, methane and perhaps traces of ethane. Radiation increased the rate of oxidation of at least one of the coals studied. All of the coals reacted with nitrogen in the presence of radiation. A mechanism is proposed for the non-radiative oxidation of the coals. There were no significant differences in the Gieseler fluidities of the irradiated and un-irradiated coals. There were also no significant differences in the rates of gas evolution or in the types of gas and coke produced by 850°C carbonization of the irradiated and un-irradiated coals.

Shock Waves

Shock Wave Studies by Mass Spectrometry. I. Thermal Decomposition of Nitrous Oxide. J. N. Bradley and G. B. Kistiakowsky. *J. Chem. Phys. 35,* 256 (1961) July (8 pp.)

An apparatus is described in which the reacting gas behind a reflected shock wave is sampled continuously and analyzed at intervals of 50 or 100 μsec by a time-of-flight mass spectrometer. The thermal decomposition of N_2O in the temperature range 1780-2000°K has been used as a test case to demonstrate that the experimental technique is valid. It has also been shown that the mechanism and rate constants of this reaction at high temperatures are consistent with earlier measurements at much lower temperature.

Shock Wave Studies by Mass Spectrometry. II. Polymerization and Oxidation of Acetylene. J. N. Bradley and G. B. Kistiakowsky. *J. Chem. Phys. 35,* 264 (1961) July (7 pp.)

The polymerization and oxidation of acetylene have been investigated at temperatures from 1800°-2700°K and 950°-1100°K, respectively, by the technique of time-of-flight mass spectrometry in reflected shock waves. In the absence of oxygen, a simple bimolecular reaction produces a dimer, probably vinyl-acetylene, and higher polymers, which appear to reach "equilibrium" with the acetylene. A sharp drop in the concentration of these polymers is observed at a later time, which is correlated with the formation of carbon after an induction period. In the presence of oxygen, a dimer, probably diacetylene, is formed simultaneously with the formation of CO and H_2O, after an induction period. This suggests that it is a product of the branching chain reaction, a specific mechanism for which is proposed.

Thermal Conductivity

Thermal Conductivity of Heterogeneous Materials. R. L. Gorring and S. W. Churchill. *Chem. Eng. Progress 57,* 53 (1961) July (7 pp.)

The thermal conductivity of a heterogeneous material may be defined as the gross heat flux density divided by the gross temperature gradient. The quantity is, in general, a function of the initial and boundary conditions and hence is not a true property in the thermodynamic sense. However, for large dimensions and steady state the thermal conductivity of a heterogeneous material is a useful engineering concept. Here is an interpretation and evaluation of the available methods of predicting conductivities of heterogeneous materials. Simple and straightforward mathematical models show good agreement with experimental data.

Tritium Mechanisms

Mechanisms of Hot Hydrogen Atom Displacement Reactions with Alkanes. D. Urch and R. Wolfgang. *J. Am. Chem. Soc. 83,* 2982 (1961) July 20 (10 pp.)

The reaction mechanisms of hot hydrogen atoms with al-

kanes have been studied. Recoil tritium from nuclear reaction was used as the source of hot hydrogen and iodine or oxygen served as scavengers to suppress interference from the minority of tritium atoms that reach thermal energies. 99.5% of the products may be accounted for by replacement of one or possibly two hydrogen atoms or alkyl groups by the incoming hydrogen. The detailed product spectrum provides strong support for a model of the mechanism in which the incoming hydrogen displaces another group directly, without forming any metastable intermediate. The point and direction of impact as well as the energy of the hot species is thus paramount in determining the course of the reaction. The greater tendency to break C-H rather than C-C bonds is then simply due to the obstruction to certain modes of impact. Hydrogen atom abstraction appears to follow axial approach of the hot atom along the C-H bond axis: while displacement occurs (without Walden inversion) as a result of attack at larger angles to the bond axis.

Stereochemistry of Hot Hydrogen Displacement at sp^3 Carbon-Hydrogen Bonds. M. Henchman and R. Wolfgang. *J. Am. Chem. Soc. 83,* 2991 (1961) July 20 (6 pp.)

The stereochemistry of the displacement of hydrogen by hot hydrogen atoms has been studied at an sp^3 carbon atom in a gaseous molecule. The system used was the reaction $He^3(n,p)H^3$, with optically active 2-butanol. There is 91 ± 6% retention of configuration for displacement of the hydrogen atom directly bonded to the asymmetric carbon. For the displacement of all the hydrogens throughout the molecule, there is 94 ± 3% retention of configuration. These results are well in accord with the model of hot hydrogen displacement postulating a fast, localized interaction occurring in about the characteristic period of a C-H bond vibration. According to such a model the short duration of the collision and the small size of the hydrogen atom allow no effective coupling mechanism for the concerted excitation of the several vibrational modes involved in the inversion process.

Viscosity

Model Experiments on Atomization of Liquids. M. Popov. *Rev. Mecanique Appliquee. 1 No. 1,* 71 (1956) (7 pp.) NASA Technical Translation F-65.

The purpose of this paper is to determine the similarity laws for the atomization of liquids with constant material properties and to verify them by comparison model experiments. The analyses show that the effect of the viscosity of the gas was very small and that approximate model experiments can be carried out without considering the ratio M of the gas to liquid viscosity, a condition that is difficult to justify. The derived and experimentally verified similarity laws permit the modeling of the atomization processes of liquids whereby considerable simplifications in experimental procedure and generalization of the experimental data are made possible.

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